Engineering Record

A Weekly Journal Devoted to Civil Engineering and Contracting

Published by McGraw Publishing Company, Inc.

Volume 70 — NEW YORK, SATURDAY, OCTOBER 17, 1914 — Number 16

Anchoring Base Plates

TESTS made to determine the load distribution of various types of base plates and the frequent discussion of the distribution of loads on foundations indicate a very wide interest in this general subject. Attention is therefore directed to the article on page 441, indicating that the method usually employed for the computation of maximum stresses in the masonry under base plates is apt to be seriously in error. Attention should be called, however, to one point—that the method proposed does not apply when the resultant falls within the base plate, unless an initial tension has been placed on the anchor bolts. Where the nut has not been brought up with considerable force and the bolt is not called into play, the formula applying in the case of a material which cannot resist tension should be applied.

Self-Supporting Arch Reinforcement

REINFORCEMENT heavy enough to support itself, the forms and the concrete has been proposed for several large bridges in the United States, but has not been used on any considerable scale until the large viaducts were built at Fort Worth. In Europe this type of construction was used as far back as 1897, but its justification, under American conditions, can be found only in rare cases. The reason for the rejection of the design heretofore in the United States has been solely on the ground of cost. Competitive bids between self-supporting reinforcement and wood or steel centers, either self-supporting or carried on falsework, have been received on several large jobs, and in every case the self-supporting reinforcement was the most expensive type. In all of these cases, however, there was ample room for the falsework, and no serious obstruction of waterways subject to flood was involved. At Fort Worth, however, clearance was a vital matter and under those conditions the engineers considered the self-supporting type as the most desirable. On account of its infrequent use, however, even in Europe, engineers will turn with considerable interest to the brief description of the work given on page 437 of this issue.

Filter Limitations

THERE has been a decided aversion among sanitary engineers in the United States against fixing definite standards of purity for raw and treated waters. This is because conditions vary so widely in different localities. What is suitable for one place may be entirely unreasonable in another. In England the Royal Commission has specified requirements for the cleanliness of rivers and it seems probable that before the work of the International Joint Commission, which is studying the pollution of the boundary waters between the United States and Canada, proceeds much further there will have to be some ruling on the question of what is permissible pollution. It is evident that the decision will have a very vital bearing upon the matter of water filtration and in this connection the paper on limitations of water filters which George W. Fuller presented last week at the Boston convention of the American Society of Municipal Improvements is particularly timely. It is published in abstract on page 442. Mr. Fuller concludes that it is reasonably safe for a modern filter, with sterilizing equipment, to treat a raw water having a B. coli content not exceeding 500 per 100 c.c., based on yearly averages. Filters have accomplished such wonderful results that many people believe that they are infallible remedies for any kind of dirty water. They have their limitations, however, and, as Mr. Fuller points out, they must not be burdened with an unreasonable load.

Fair Play

A WORD of appreciation of the work being done by the New York State Highway Commission is in order. The investigations of 1913 so staggered public confidence that naturally the average observer still considers the State's road activities with a prejudiced mind. Those who visit the offices or study the field methods of the present organization will recognize how unjust this feeling is, especially as the offences were largely not charged to the men now in office. There is a spirit among the members of the organization highly gratifying to one who meets them at their work. In office, field or laboratory is apparent a high enthusiasm for the program laid down by Commissioner Carlisle and his associates. One division chief recently threw light on his methods when he said: "No man in this organization is ever able to say that his work is finished!" It is undoubtedly to the adoption of new and high standards in workmanship and conduct that this excellent result is to be credited. The observer, quick to condemn misfeasance in the administration of a vast public trust, should be as ready to acknowledge faithful, efficient work. Doubtless there are those who would still like to use the organization for their own ends, but the present spirit encourages one to believe that no man will with impunity attempt to destroy what has been built up. The work being done this year should go far toward dissipating the suspicious attitude held toward the organization by those not close to its work. Fair play requires recognition of the present activities.

Farmers Not Settlers

AT the twenty-first International Irrigation Congress, held at Calgary, Oct. 5 to 9, much attention was given to the type of farmer needed and the kind and disposition of crops. "Farmers not settlers" crystallizes the evident sentiment as to the type needed—men able and willing to till irrigated lands according to practice demonstrated to be successful. "Grain-mining is not farming" was another sentiment unanimously approved. The continued effort to raise grain only, year after year, because it is a cheap and ready way of getting a little money, was shown to lead inevitably to ruin. The efforts of all owners or managers of irrigation projects should be to bring in more live stock, especially dairy cows and hogs, and to induce and aid the settlers to work up their bulky produce on the farm, reducing to a reasonable minimum the sale of grain and hay, which removes the fertility from the farm, and increasing the manufacture, if it may be so termed, of finished products—milk, butter, eggs, pork, mutton and beef—"packing the hay and grain into butter fat or into the skin of a hog." A favorable sign also was the interest displayed in the systematic measurement of water, and the proper valuation of the supply, basing the farmers charges or taxes on these measurements. This is the surest way of checking over-irrigation, and the serious results certain to follow in its wake.

Bleeding Paving Blocks

A THOROUGH understanding of facts is always the first step toward improvement, and it is for this reason that Mr. Teesdale's paper, read at the convention of the American Society of Municipal Improvements last week, should interest municipal engineers who have had trouble with the bleeding and swelling of creosoted wood-block pavements. His conclusions seem to indicate that bleeding and swelling are not due primarily to the type of material used, but rather to the method of treatment. Latterly there has been considerable discussion as to the likelihood of straight creosote-oil blocks being freer from bleeding than those treated with an oil containing considerable percentages of tar. In Mr. Teesdale's experiments both straight creosote oil and oil mixed with tar were used. The fact that in his conclusions he does not indicate that blocks treated with the one material bled or swelled more than those treated with the other indicates that this factor had very little influence. It can hardly be assumed that his conclusions are final, since the tests are quite few. It is worth recalling, though, that the sentiment at the New Orleans meeting of the American Wood Preservers' Association last

January inclined to the view that the impregnation with a tar-mixed oil was as good as that with a straight creosote oil. In fact, at the same meeting results secured by Messrs. von Schrenk and Kammerer were reported, indicating little difference in the degree of absorption. Municipal engineers, therefore, may very well turn their attention to methods of treatment. Quality of oil, of course, must not be left out of consideration. Rather, the scrutiny of the oil and care in writing specifications for it must be as stringent as ever, but superadded must be an appreciation of the effect upon the block of the character of treatment. The conclusions, as given on page 444 of this issue, indicate the desirability of treating the blocks in a green condition after thorough steaming. Mr. Teesdale also believes it advisable to apply a vacuum after the steaming period and also after the oil has been removed from the cylinder. As was to be expected, he objects to the very heavy impregnation now called for in most specifications and advises a maximum limit of 16 lb. of oil per cubic foot. The paper is valuable in that it suggests a means by which the serious objection made to wood block pavement by citizens who have to use the streets in hot weather may be overcome. Further conclusions from Mr. Teesdale's experiments will be welcomed by municipal engineers.

Rational Methods and Guesswork in Sewer Design

A CONUNDRUM for which a clean-cut answer has yet to be given is offered by the common practice in estimating the size of a proposed sewer. Why is it desirable, after estimating the total volume to be carried, to make the sewer so large that this maximum will fill only half the cross-section, or two-thirds in the case of very large sewers? Engineering books and society proceedings give no satisfactory answer. The engineer who designs sewers has accepted custom as a guide, feeling that it leads to safety, at least, but he is usually willing to acknowledge that this practice of making a sewer larger than is required to discharge the maximum estimated volume is not logical. It is simply adding a blind guess to a number of more intelligent assumptions.

The selection of the size of small lateral sewers is a matter in which judgment must exercise the controlling influence, but this is not true in the same sense in the case of larger sewers. The methods of estimating the future population of a district and the amount of sewage to be expected from it for a period of 20 to 30 years have been well established. The rational method of estimating the storm-water runoff from a district is surprisingly accurate when used with the care and good judgment shown, for example, at St. Louis, as described in the articles now appearing in this journal. The leakage of ground water into a whole system can be estimated quite closely, although the estimate for any small section is more difficult, and if the amount of ground water and the character of the workmanship of the proposed sewers are unknown, the engineer's conclusions must be formed very carefully. Industrial sewage is sometimes of surprisingly large volume, but the determination of its amount is not often a very troublesome problem.

It is practicable for a well-informed engineer of good judgment to form a reasonably good estimate of the storm-water runoff, the house and industrial sewage, and the leakage. Where his knowledge is limited, owing to lack of accurate local information, he can be more liberal in estimating quantities than where the conditions are more clearly defined. In each of these elements, which combine to make the total quantity to be provided for, the engineer is able to make definite and logical allowances for the future, and the total quantity thus obtained is apparently that which the sewers should be designed to carry when running full. What, then, is the reason for making the sewers so much larger than is necessary to carry the maximum quantity likely to reach them during the period of years for which they are planned to furnish adequate service?

A Question of Society Ethics

LAST week's meeting in Boston of the American Society of Municipal Improvements emphasized an evil that must be corrected if scandal is to be avoided. This evil is the domination of important committees of this and other associations by engineers and experts who are identified with commercial interests which may be affected by the action of such committees. Very properly the society has barred from its committees and deprived of the voting privilege those engineers, chemists and other experts who are regularly employed by a manufacturer. But at the same time there is at the head of one important committee of the society a man retained by a group of manufacturers whose interests are identical. And the only difference between this expert and those who are barred from effective participation in the society's affairs is that the latter are on the payroll of single manufacturers while those who enjoy full activity in the society are paid by fees from several manufacturers.

It is no reflection upon anyone to say that this is an improper condition. In professional relations even the appearance of possible evil must be avoided, and in the case in point it does not help matters to have a committee report, prepared by an expert regularly retained by a branch of an important industry, adopted without examination or opportunity for consideration, and especially when it appears that the report is wholly to the advantage of that branch of the industry with which the expert is closely identified.

Municipalities that do not do their own thinking sometimes swallow these association specifications with their eyes shut. This is unwise, however good specifications may be; it is the climax of foolishness if the specification swallowed turns out to be one drawn in the interest of manufacturers and adopted after a hurried reading by a scattering of association members who, even with the best intentions in the world, could not know exactly what they were voting for. Obviously this condition of things imposes a solemn obligation upon such organizations as the American Society of Municipal Improvements to keep their actions free from even the suspicion of undue influence or snap judgment.

This journal does not propose to go into the merits or demerits of any report presented at the Boston meeting; nor does it attribute any unworthy motives to anyone. It does, however, assert it to be a fact that the chairman and one other active member of one committee made a report on asphalt specifications which was very much in the interest of manufacturers who are the clients of these committeemen; that the chairman of the committee is not a city official or in any true sense an independent expert, and that he was the active opponent of an effort by the engineer of an important city to secure time for consideration of this report. The report completely reverses in a very important particular the position of the Association for Standardizing Paving Specifications, which has been followed by many smaller cities, and but for the pressure exerted by the proponents of the change, it, like the wood-block specification report, would have been held up at least until there was an opportunity for more careful consideration than is possible in a hurried open meeting. The wood-block specification now on record is of rather malodorous memory, and, as this journal understands it, an amendment thereto that was, to say the least, no moral improvement was barely postponed at Boston.

If the American Society of Municipal Improvements is desirous of retaining its reputation and the respect of engineers and officials it cannot allow this sort of thing to go on. There was an intimation by one of the officials at the Boston meeting that the executive committee intended to take up the question of limiting its active, i.e., voting, membership to city officials. Perhaps this would bar out some very useful members. But certainly the society can avoid placing on and at the head of its important committees men retained by manufacturers whose interests are affected by the actions of the society. It cannot act too soon to prevent criticism of a kind which is fatal to professional associations, and the only safe, proper, and defensible action for the American Society of Municipal Improvements to pursue is strictly to limit its voting and committee membership to active city officials.

Societies and Specifications

ELSEWHERE in these columns will be found an editorial on "A Question of Society Ethics," commenting upon the recent meeting of the American Society of Municipal Improvements. In the concluding paragraph the opinion is expressed that the society should bar from its committees all representatives of manufacturing interests, while the possibility of the society excluding from active or voting membership all but city officials is referred to.

This brings up the whole question of the relation of societies to specifications. To apply the recommendation of the editorial referred to to all technical societies would be wrong—in support of which statement there is the remarkable record of the American Society for Testing Materials, in which producers and consumers are represented, and whose committees must, in accordance with the rules of the society, include representatives of both classes.

If, then, there are societies in which membership by producers is desirable and some in which it is undesirable, where is the line of demarcation? Doubtless there are many factors that need consideration before this question can be satisfactorily answered. Two, however, can readily be stated—first, the society which includes manufacturing interests must be a large one, and, second, the makeup of committees and the method of drawing up, considering and adopting specifications must be hedged about with the very greatest precautions.

Large membership is desirable in order that there may be brought together a sufficient number of specialists, representing both the manufacturing and consuming interests, to have all shades of opinion properly presented, thus insuring specifications which adequately cover the ground and in the formulation of which every phase of the subject has been given adequate consideration.

The elaboration of the machinery for adopting the specifications is exceedingly important. The method used by the American Society for Testing Materials is the result of years of study and experience. There the consuming interests must form half or more than half the membership of each committee. Following approval of a specification in committee, a stage reached only after due consideration, the proposed specifications are issued to the society, and quite generally are printed as "information" in the "Year Book" for one year before being recommended for adoption, thus affording twelve full months for careful study. During that time all "jokers," if any such should get by the committee, which is extremely unlikely, can be discovered and laid bare to the membership at the annual meeting. Needless to say, such exposures of commercially drawn specifications never occur. The very machinery dissuades anybody with improper designs from placing his clauses even before the committee.

If, then, such an elaborate procedure has been found necessary in a large society which has attracted to its membership the most eminent specialists in the country, how can trustworthy results be looked for in a small society where those safeguards are lacking? In a small organization the only hope is in the direction advised in the editorial above referred to—that only consuming interests be admitted to committee membership. This practice is, indeed, followed out by some of our most successful technical societies.

A further suggestion may not be amiss in this connection—that the smaller societies, such as the American Society of Municipal Improvements, instead of writing their own specifications call upon the American Society for Testing Materials to organize suitable committees when the lack of specifications in any particular line is discovered. The latter organization is in a flourishing condition and in a position to handle all important material problems coming before engineers. There would be no reason to fear that in that society the manufacturing interests would control. On the other hand, specifications of smaller societies drawn by committees controlled by manufacturers have been used by those producers in the exploitation of their products, while simultaneously they gave the unthinking consumer to understand that the specifications were the conclusions of a body eminently qualified to pass them. The influence of the American Society of Municipal Improvements has been very greatly lessened because of some specifications it has passed, and engineers familiar with its operations are now quite distrustful of what it puts forth.

There are but two remedies. Either the society must confine its committee and active membership to the consuming interests, or specification-making must be turned over to the American Society for Testing Materials. And of the two, the Engineering Record believes that the second is the better plan. It is right to consider the manufacturing problems entering the production of materials. In the American Society for Testing Materials these problems will be given proper consideration, without allowing the producers to bend them to their commercial advantage and to the detriment of the consumer. In the smaller society there is very grave danger that such will not be the case.

Status of Water Analysis

A MARKED change has come over the status of water analysis since the days of Nichols, Drown, Mallory and Leeds, a generation ago. Then the science of bacteriology was in its infancy and most of the tests were chemical. From these the analyst made his findings and commonly issued a rather dogmatic verdict, which none could gainsay, whether it were right or wrong. The tests were relatively few in number and their cost was high. A single sample was tacitly assumed to represent an entire water supply for a long period; that is, a given water supply was assumed to have an individuality and a constancy such that one sample, or at most a very small number of samples, gave an adequate idea of its character. As the analyses came to be made in larger numbers it was found that the water in any supply was by no means constant in quality, that river waters vary from day to day and even from hour to hour, that lakes and reservoirs are not homogeneous, and even that well waters have their seasonal changes. It was also found that the so-called interpretations often led one astray and that the usual rules were accompanied by so many exceptions as to lose most of their force. In the early days water purification was used only to a very limited extent. Now it has become a recognized principle that nearly all surface waters need purification, and filtration plants and other methods of purification are found in most cities supplied with surface water and even in cities where well water is used.

The principal use of water analyses today is in connection with water purification. The great problem is no longer that of passing judgment on the quality of water by interpreting an occasional analysis, but that of measuring the efficiency of a filter or the effect of storage or of the application of some disinfectant. For these purposes direct results are wanted, not results that need elaborate interpretation. Much less emphasis is placed upon free and albuminoid ammonia, upon nitrates, nitrites and chlorine, and more upon such tests as those which determine turbidity, color, hardness and iron, and the number of bacteria and of B. coli present.

These matters are strikingly brought out in the preliminary report of the Committee on Statistics of Water Purification Plants, presented to the New England Water Works Association at its recent convention in Boston. Confronted with two opposing conditions—the need of frequent sampling and the prohibitions placed upon it by cost —no single solution applicable to all places can be reached. The committee has adopted it as a general principle that the frequency of sampling is to be governed chiefly by the frequency of change in the quality of the water. Three grades of control are established for filter plants—a first grade, where analyses are made daily by a resident analyst; a second grade, where analyses are made regularly on a weekly or monthly basis; and a third grade, where the analyses are made irregularly and infrequently. Another principle is that polluted waters require that a purification plant be operated with a higher factor of safety and a more careful analytical control than do waters of better original quality. A corollary to this would be that small places which cannot afford a high-grade control should have a safe source of supply and seek protection in storage and works that normally possess a high factor of safety.

The committee also calls attention to that unsatisfactory method of measuring the efficiency of a filter known as "percentage removal of bacteria." Apart from the number of bacteria in the raw water this percentage means but little. It shows neither the hygienic efficiency of the filter nor the quality of the filtered water. In its place a more detailed statistical study of the analyses of the raw and filtered water is to be substituted. What the water consumers and the public health officials really want to know about a filter is for what percentage of the time the water is safe. This brings up again the old question of what is pure water, or, better, safe water.

Those who have followed Hazen's application of the theory of probability to stream flows, as given in his recent paper before the American Society of Civil Engineers, will be prompt to recognize that the same principles are likely to be applied to the results of the analyses of water. In other words, the statistical method is to supersede dogma in this field just as it has in other branches of natural science.

Special Steelwork in the Morgan Building, New York City

Need for First Floor Unobstructed by Interior Columns Led to Extra-Heavy Long-Span Trusses and Suspended Upper Floors

THE new four-story steel frame building for J. P. Morgan & Company, New York City, occupies an irregular area, about 110 x 150 ft. in extreme dimensions, at the corner of Wall and Broad streets. The building is to be used for banking purposes and it was required that the entire lower story should be unobstructed by interior columns. Hence the three upper floors are supported entirely from the wall columns and from a series of very heavy long-span trusses and plate girders in the roof.

MAIN TRUSSES

There are four main trusses extending across the full width of the building and supported directly by the wall columns except in one place where the end of a truss is carried by a heavy plate girder. The trusses have spans of from 77 to 98 ft. They traverse the fourth story, which is 10½ ft. high in the clear; their top chords are in the hip roof surface and their bottom chords in the fourth floor. The second and third stories are of ordinary height and the first story is 37 ft. high, thus giving the bottom chords of the trusses a height of 63 ft. above the first floor or 114½ ft. above the basement floor, which is carried down to a maximum depth of 48 ft. 10 in. below curb level.

The trusses are all of riveted construction with stiff members throughout, most of which are made in pairs, thus practically constituting twin trusses with the web members connected to the chords by heavy pairs of gusset plates. The end posts are inclined at different angles to correspond with the requirements at the hips. The trusses weigh from 50 to 113 tons each, the largest ones having a maximum top-chord section of 157.2 sq. in. and a net bottom-chord section of 150 sq. in.

The trusses are seated directly on the tops of the columns to eliminate bending stresses which would be developed if the columns were carried up continuously through the trusses to the top chords. Both trusses and columns have wide gusset plates stiffened with vertical angles to provide adequate bearings for the heavy shear. The bearings are thus made on horizontal surfaces, largely eliminating the transmission of stress through rivet shear, and simplifying the connections.

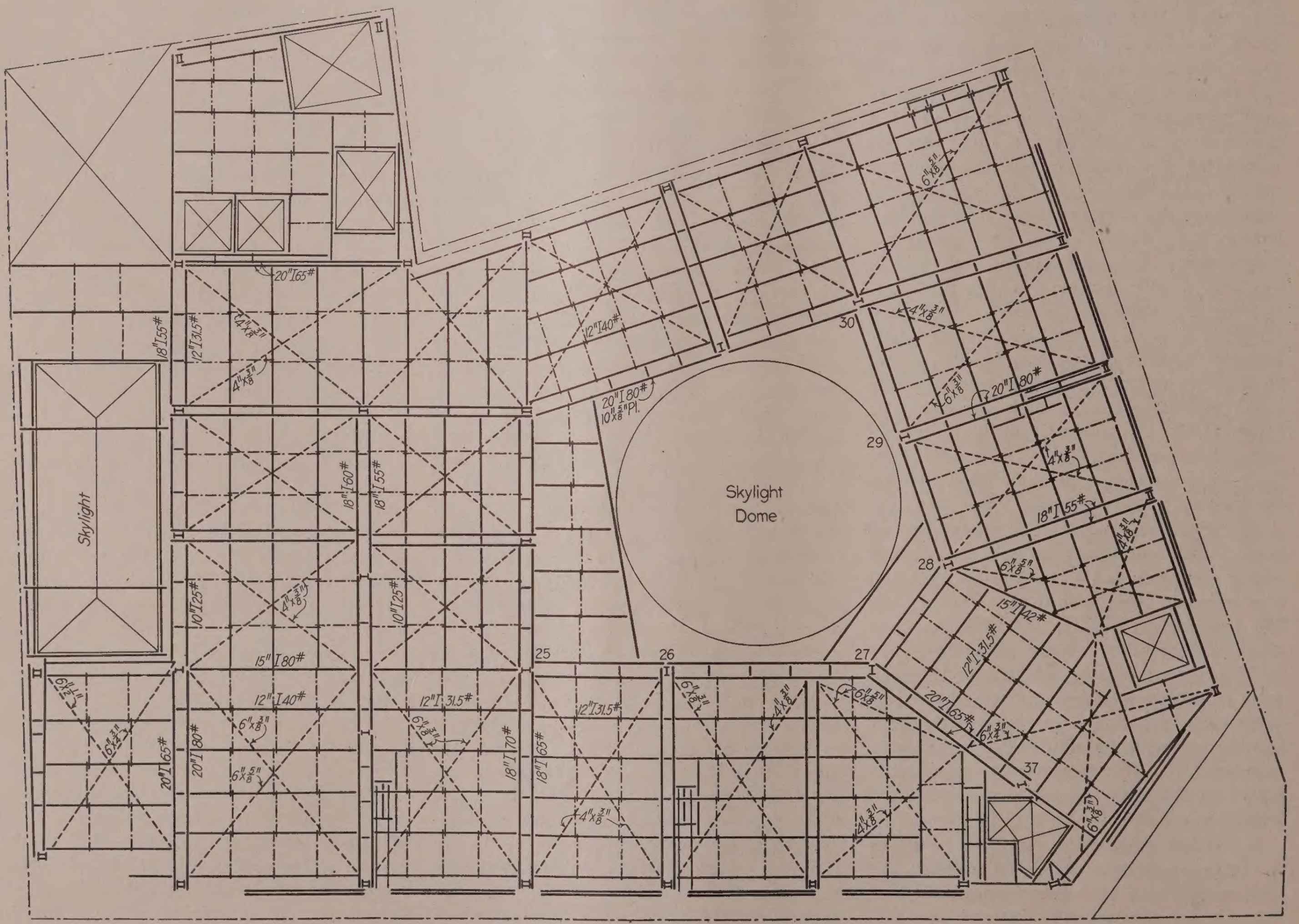
LONGEST TRUSSES

Details of the trusses are shown. Truss D, which has the longest span, is unsymmetrical on account of the different slope and length of the inclined end posts; one of these is short and steep while the other is long and flat and has several inclined intermediate braces. The intermediate panels are regular and are similar except that the vertical post is omitted at the center bottom-chord panel point.

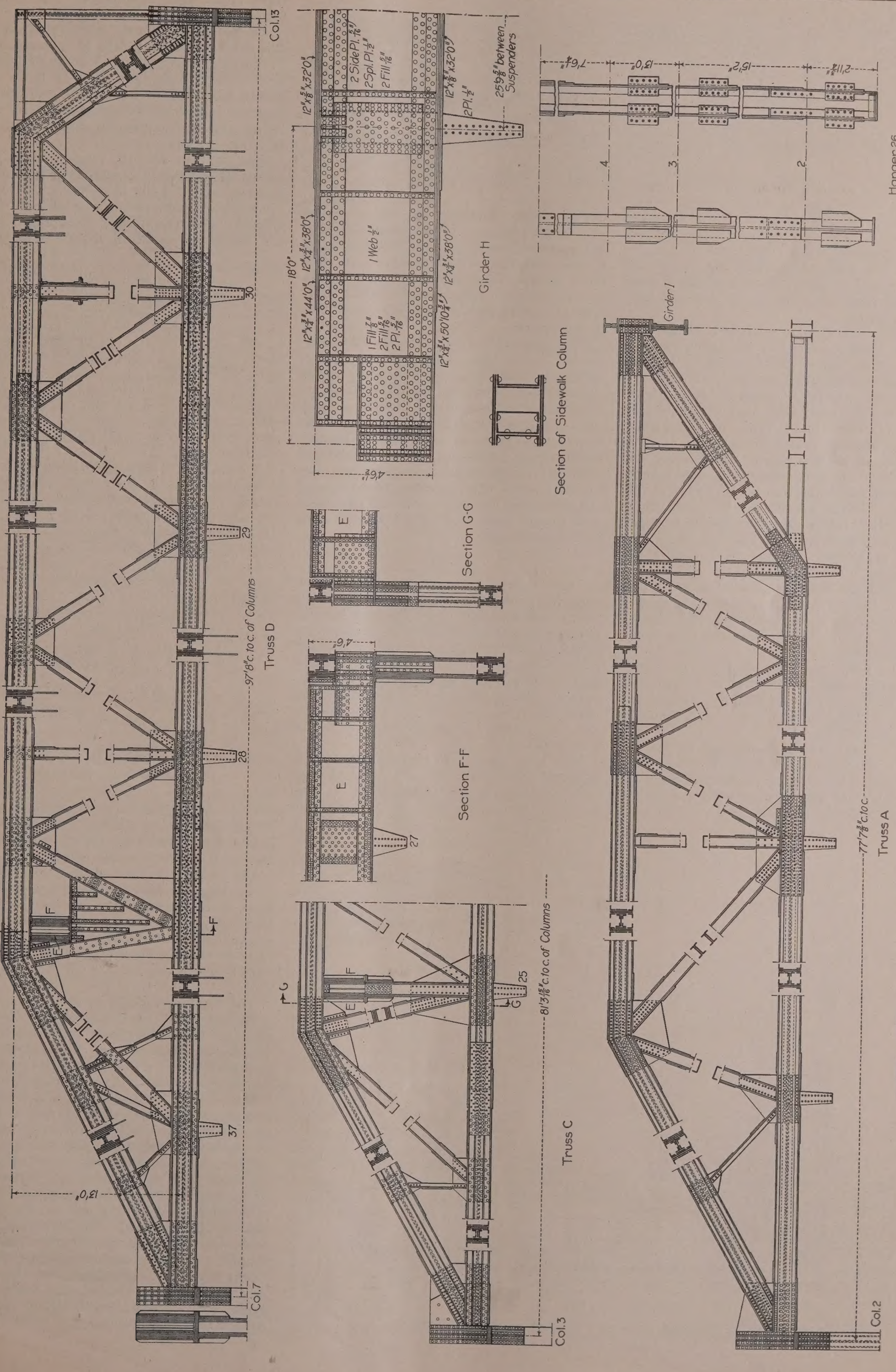
The top chord has an H-shaped cross-section made of two built I-beams connected by a continuous horizontal transverse diaphragm on the center line and by batten plates and lattice bars on the flanges. Each half of the chord has three full-length 24-in. web plates with a combined thickness of 1½ in. riveted between a pair of 6 x 3½ x 9/16-in. angles for each flange and reinforced by a 12 x ⅜-in. plate between the flange angles. The connecting diaphragm is made of four full-length 6 x 4 x ⅜-in. angles and one 9 x ⅜-in. web plate. The bottom cord is substantially the same except for a difference in the thickness of the angles.

At one end of the truss the bottom-chord gusset plates extend nearly to the top chord, forming large heavy webs reinforced with vertical angles, and making, with the braces in the long end panel, a construction almost equivalent to plate-girder work to resist the heavy shear.

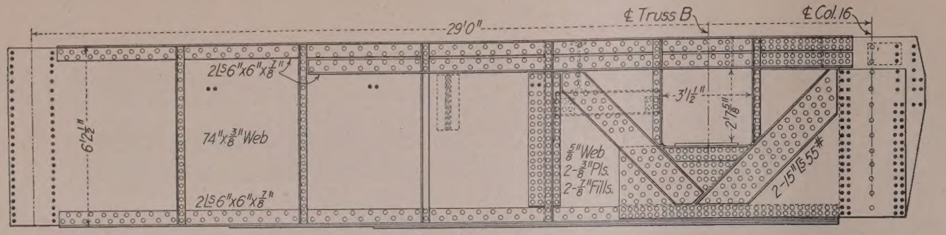
Near one end the truss supports the plate girders C and F, which, near their center points, carry suspenders for a portion of



SECOND-FLOOR FRAMING PLAN OF MORGAN BUILDING, SHOWING POSITION OF SKYLIGHT DOME



GENERAL DIMENSIONS AND PANELING OF THE PRINCIPAL ROOF TRUSSES, AND DETAILS OF GIRDERS, COLUMNS AND HANGERS



DETAILS OF GIRDER I, WHICH SUPPORTS ONE END OF TRUSS B

the floor near the dome. The top flanges of these girders are flush with the top chords of the truss. The ends of the girders are notched to clear the latter and are seated on flange bearing angles riveted to the large web connection plates already referred to.

Truss C is similar to truss D except that it is shorter and that its members have somewhat lighter cross-sections. Trusses A and B are much lighter and shorter.

Girder I, which supports one end of truss B, receives from it a load of 500,000 lb. 5½ ft. from the bearing of the girder. This produces maximum stresses of 230,000 lb. in the top chords, and 240,000 and 94,000 lb. in the adjacent diagonal members by which the web is reinforced at this point. As the top chord of the truss passes entirely through the girder in order to give adequate bottom-flange bearing, the girder web is cut to curve and reinforced at the bearing to a total thickness of 3⅜ in. At one end the reaction of 472,000 lb. is provided for by seventy-eight ⅞-in. rivets in double shear. At the other end the reaction of 140,000 lb. requires only forty-eight rivets.

The plate girder H supports the intermediate rafters of the hip roof, and with the companion girder beam G carries two floor suspenders with loads of 276,000 lb. and 302,000 lb.

The intermediate floorbeams of the second, third and fourth stories are field riveted to the vertical suspenders from the roof trusses and girders with connections either directly to their flanges or to hitch angles shop riveted to the latter. They are of simple construction with I-shaped cross-sections made of four full-length 4 x 4 x ⅝-in. flange angles and a ½-in. web plate varying from 11½ to 13 in. in width to correspond to suspender 26, herein illustrated, except in the details and connections to floorbeams.

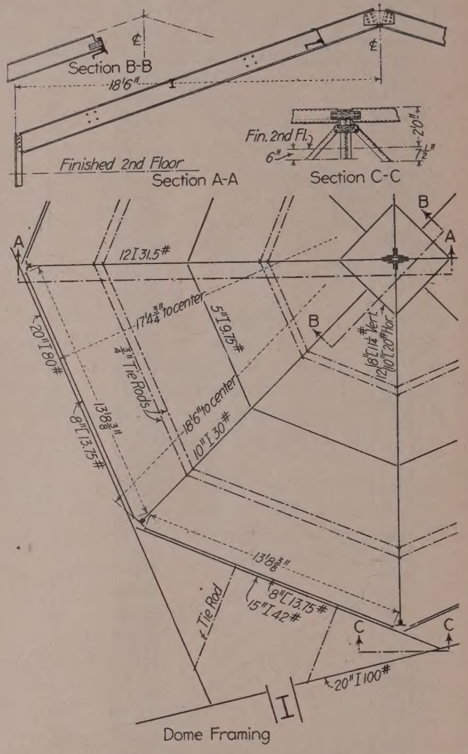
The general construction of the suspended floors two, three and four corresponds to that of the second floor, except that the dome framing is omitted in them. The floorbeams are double H-beams engaging both flanges of the suspenders, and the floor joists are single H-beams. The suspended floors have solid continuous slabs of 4-in. reinforced cinder concrete and are braced against wind stresses, vibration and swinging motion by horizontal diagonal bars in each panel riveted to the top flanges of the floorbeams.

DOME

The skylight dome at the second-floor level has a superficial area of about 1650 sq. ft. and is carried from the roof girders and trusses through the vertical suspenders and floor construction to which it is framed. It has a diameter of 36 ft. and is octagonal in plan with eight radial rafters and sub-rafters pitched about 1:3, and connected at their lower ends to the floorbeams and to auxiliary corner I-beams as indicated in the part plan.

The four main rafters intersect at the summit, where they are cut to clear and are connected by web splice plates. The intermediate sub-rafters are framed at their upper ends to a 4½-ft. rectangular drum which has an L-shaped cross-section made of two channels riveted together. The sub-rafters are braced at center points by an octagonal system of horizontal purlins. The panels each side of them are stayed with double sets of tie rods introduced to reduce the slenderness ratio of the rafters, which carry compression as well as bending stresses.

The interior columns support only the basement and first floor and have maximum loads of only 370,000 lb. They have closed rectangular cross-sections made of two channels and two flange coverplates, and are seated on cast-iron bases. The wall columns have cast-iron or cast-steel bases or solid steel slabs, distributing their loads over the grillage beams or, in two cases, to the top flanges of cantilever girders.

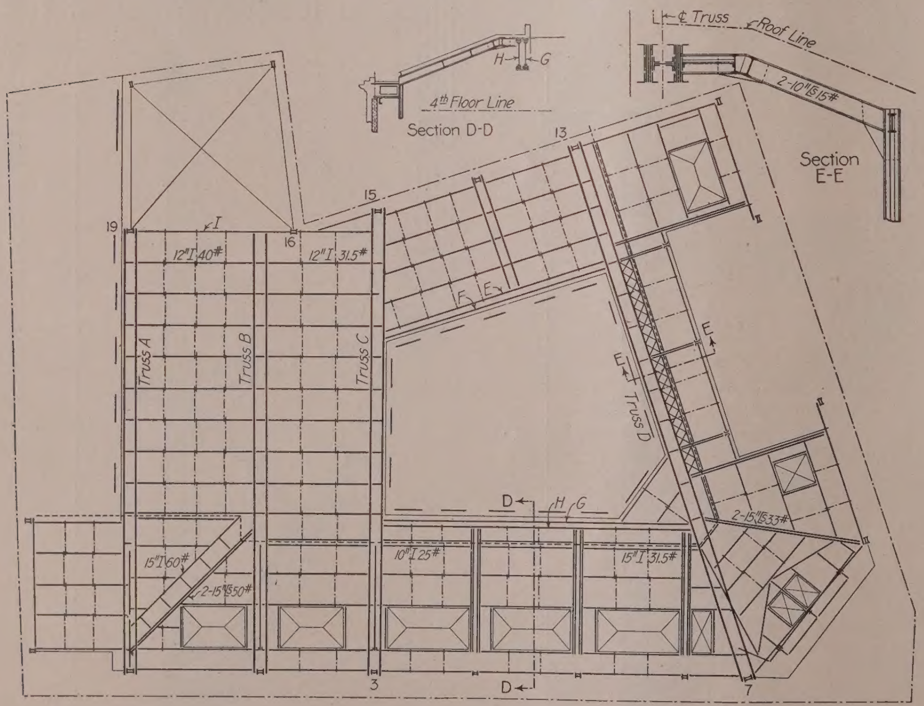


DETAILS OF DOME FRAMING

The seven columns on the Wall Street front support heavy girders at sidewalk level, which increase the stresses so much that their lower portions were made with special cross-sections having extra channels or pairs of channels introduced between the flange coverplates to care for the sidewalk load.

The maximum stress in these columns is 1,450,000 lb., which is provided for by the sectional area of 125 sq. in., made up of four 15-in. channels, one 14 x 7/16-in. web plate and two 24 x ¾-in. and two 15 x ¾-in. flange coverplates. This column receives a load of 488 tons in addition to the floor and sidewalk loads. The maximum truss load of 479 tons is transmitted to column 13, which in the upper part has a cross-section of 86.6 sq. in., made up of two 12-in. channels and two 16 x ¾-in., three 16 x ⅞-in. and two 11 x ½-in. plates.

Trowbridge & Livingston are the architects of the building. The structural steel work was designed by Weiskopf & Burroughs, consulting engineers. Post & McCord were the contractors for the steel work, which they erected, the fabrication being done at the Pencoyd plant of the American Bridge Company.



ROOF PLAN, SHOWING LOCATION OF THE FOUR MAIN TRUSSES

Structural Steel Design for the Morgan Building

Discussion of Various Problems Not Ordinarily Encountered, and of the Way They Were Analyzed and Solved

By H. R. BURROUGHS
Of Weiskopf & Burroughs, Consulting Engineers
New York City

THE structural steel for the J. P. Morgan & Company building embodies a number of interesting features which do not obtain in the ordinary type of construction. The general layout for the steelwork is in many respects irregular, as the column centers have no general arrangement of alignment and the interior columns support only the basement and first floor. The wall columns, as stated in the foregoing article, are carried up and support indirectly the upper floors and roof, there being no interior columns in the first story. This leaves the entire first floor clear for use as a banking room. The second, third and fourth floors are carried by hangers, which are suspended from heavy trusses, which span from wall to wall in the fourth story.

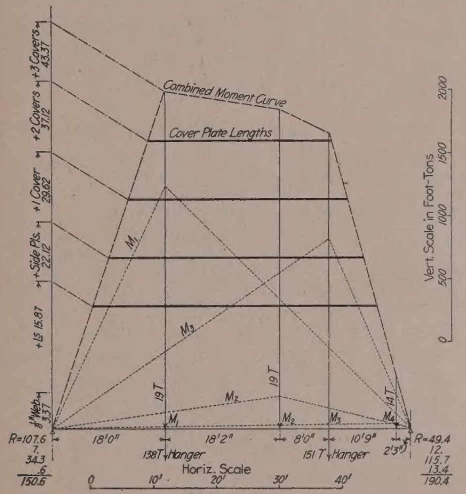
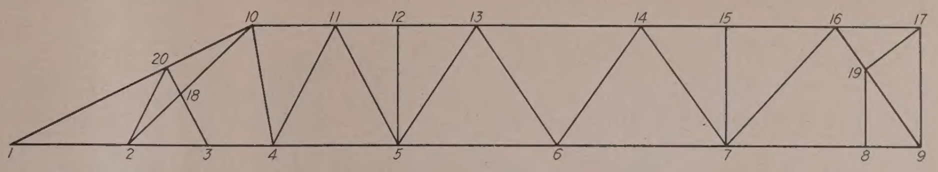


FIG. 1—TYPICAL BENDING MOMENT DIAGRAM

In preparing the steel design the following unit values were assigned for dead loads:

Material	Lb. per cu. ft.
Brick	120
Cinder concrete	100
Cinder fill	72
Granite	170
Stone concrete	150
Cement floor finish	12

In computing the dead load per square foot of floor suitable allowance was made for the weight of steel and concrete haunches inclosing the bottom flanges of beams and girders. For the first floor and basements a live load of 150 lb. was taken and for the upper floors a live load of 75 lb. was assumed, with 50 lb. live load for the roof. These loadings are in accordance with the New York building laws. Combining the live load with the dead load gave 170 lb. per square foot total load for the second, third and fourth floors, 160 lb. for the roof and 300 lb. for the first floor and basement. The dead load for the first floor and basement was unusually heavy, due to the fact that a heavy 6-in. concrete slab was adopted as a means of a horizontal support for the caissons. The grillage design was of the ordinary beam type with steel slabs, except for the interior columns, which were supported on cast-iron bases resting on concrete piers, as these loads were comparatively light. The column loads were carried down under these assumptions in the usual way and the columns proportioned in accordance with the New York building-law formula of $15200 - 57l/r$, in which l is the strength and r the radius of gyration, both in inches.



BEAMS AND GIRDERS

To floorbeams and girders of rolled sections were assigned the value of 16,000 lb. per square inch in extreme fibre, and these sections were proportioned accordingly. Plate girders and riveted sections were designed with 14,000 lb. per square inch net-section flange area, making due allowance for rivet holes. The value of 10,000 lb. per square inch was used for maximum shear on net web sections, due allowance being made for rivet holes. Wherever the clear distance between plate-girder flange sections exceeded sixty times the thickness of the web, and under concentrated loads, stiffener angles were used. At the end of certain plate girders where excessive shear was obtained reinforcing plates were employed and placed outside of the flange angles, thereby developing four shears on the rivets connecting flanges to the webs. The value of 10,000 lb. shear and 20,000 lb. bearing value was used for both shop and field rivets, as the field rivets were machine driven and thoroughly inspected.

BENDING MOMENT DIAGRAM

Bending moment diagrams were drawn as illustrated in Fig. 1, for the various girders and reinforced beams, giving the location of maximum bending moment and the size and length of coverplates. In drawing these moment diagrams the following analysis was adopted: A girder span was first sketched to scale and the loads were drawn in their respective positions with their amounts. The reactions were then computed for each load individually, the sum of which gave the total reaction. The bending moments were similarly computed for each individual load and a curve to some convenient scale was drawn at each load for each bending moment. These bending-moment curves were then combined at the various loads and a maximum-bending-moment curve drawn as shown in the sketch. The net area of the flange was then plotted on the maximum-bending-moment ordinate and subdivided in respective proportions to the angles and coverplates. Horizontal lines through these points and their intersections with the maximum-bending-moment curve determined the theoretical length of the respective coverplates as shown.

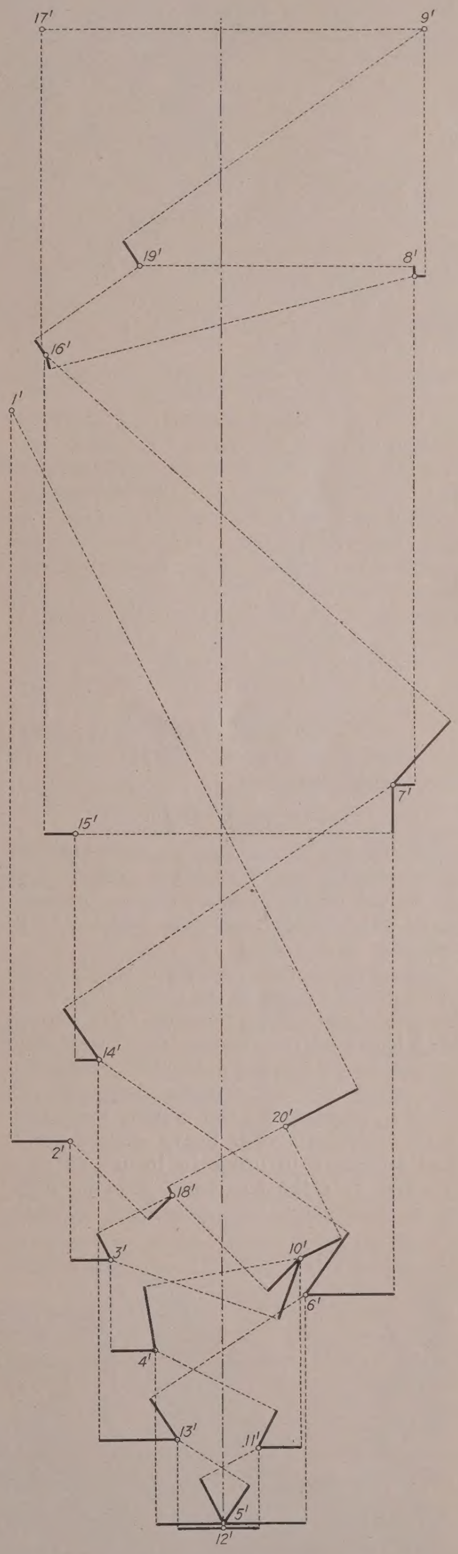


FIG. 2—DISPLACEMENT DIAGRAM OF TRUSS

DOME

In designing the structural steel frame for the skylight dome, which is located in the second floor and has a diameter of 36 ft., a total load of 100 lb. was assumed. The dome has a rise of 6 ft. at the center. The beams were arranged radially with eight radii, giving a circumferential tension of 16,250 lb., which was resisted by a band at the circumference. The radial beams were designed for combined stress, due to the gravity load and the thrust. In order to obtain a satisfactory detail at the apex it was necessary to cut back four of the radial beams, framing them into cross beams designed to take the thrust as well as the vertical load. The dome was supported by angle struts designed to take the total load at 100 lb. per square foot.

TRUSSES

The principal structural features of the building are the trusses which carry the four suspended floors. These trusses have varying spans of from 77 to 98 ft. and a depth of 13 ft. center to center of chords. The panel points were determined by certain locations of the hangers, which in turn depend on the architectural treatment of the court walls and floor partitions. This irregularity of panel points in conjunction with certain door openings necessitated an irregular arrangement of web members in the trusses. Also the slopes of the end posts were irregular, due to the given slopes of the roof and the required openings. The various loads were computed for these trusses and applied at their respective points of application, due allowance being made for the weight of the truss and the concrete fireproofing inclosing it. After all loads had been computed and the truss outline determined, stresses for both dead and live loads were computed separately by the analytical method and checked graphically, diagrams having been drawn for both full and partial loads in order to determine maximum stresses. The members were then proportioned under the allowable unit stresses of 14,000 lb. per square inch net section in tension and of $15{,}200 - 57l/r$ lb. per square inch for compression, in accordance with the New York building law. The main sections of the trusses were proportioned in the shape of twin plate girders connected by a horizontal diaphragm along their center lines.

DISPLACEMENT DIAGRAM

In order to determine the exact amount of camber to be given these trusses, displacement diagrams were drawn for each panel point under maximum loading, as illustrated in Fig. 2.

The trusses were supported by steel columns which extend to the under side of the bottom chord. The columns were capped with heavy bearing plates, which were supported by an adequate number of stiffeners, which were truly milled with the columns. The ends of the trusses were likewise reinforced with heavy gusset plates and stiffeners in order to insure an even bearing over the columns. This arrangement eliminated all secondary stresses, which would be involved if they were riveted directly to the columns. The trusses were secured against lateral displacement by two heavy portal plate girders connecting two of the longest trusses together. The other trusses were tied to these trusses by a regular system of roof beams.

One truss was supported at one end by a plate girder spanning between two columns. It was found necessary to support this reaction by forming a seat in the web of the plate girder, and in order to eliminate the eccentricity which would be involved by connecting it on one side of the web, the expedient of cutting through the web and supporting the reaction concentrically was adopted. As this reaction came relatively near one of the column supports, it became necessary to reinforce the web heavily against shear as well as the top-chord angle against the combined stresses of direct compression and flexure.

The top chord of the largest truss had an excessive unsupported length and in order to provide a means of support against buckling a horizontal system of angle lacing was introduced, connecting one line of roof beams to the main top chord, thereby incorporating this line of beams with the chord, forming a composite column.

Impressions of London's Pavements

Administration of Street Work Compared with New York's—Performance and Costs for Pavements—Traffic Details and Street Cleaning

By HENRY WELLES DURHAM
Chief Engineer, Bureau of Highways, Borough of Manhattan, New York City

A MISCONCEPTION of the characteristics of English pavements exists to a large extent, as is evidenced by frequent comparisons between our streets and those abroad to the discredit of the former, shared even by a majority of our engineers. This is due, it would seem, to the tendency on the part of the casual traveler to accept as universal custom his cursory observations.

Following his attendance as a delegate at the International Road Congress held in London in 1913, the writer, by direction of Mayor Gaynor, made a study of the paving practice in the leading cities of Europe, including all of those resembling New York in size and extent of commerce and manufacturing, and many others of lesser importance but still capable of being ranked as large cities and possessing paving problems of interest. Of these the British capital is probably referred to most often in making comparisons and is the only one of equal or greater magnitude than New York.

With the purpose of presenting to engineers some of a fellow engineer's impressions of the streets of London as compared with those of Manhattan the following extracts from his notes are given:

The greater city of London is formed of thirty independent boroughs, each with an independent administrative organization of its own. The city of London proper, including the busy square mile in the heart of the metropolitan district, and the city of Westminster are the most important of these special divisions, and the controlling organization of the former may be taken as representative of many.

ORGANIZATION IN LONDON PROPER

There are in this, the core of the metropolis, 7 mi. of asphalt and 6½ mi. of wood block, the latter being used when in the judgment of the city engineer the grade is too heavy for asphalt. The maximum grade on which the wood pavement is laid is 5 per cent. The remaining mileage of streets is paved with stone blocks and includes many alleyways and narrow streets of importance only for the access of trucks to warehouses.

The engineering organization in control of pavements under the city engineer is comparatively simple, consisting of an office staff of assistant engineers and clerks and an outside force of inspectors. All repaving, as well as all maintenance work, is done by contract. The following prices give the approximate original costs at the present time: Asphalt, including a 9-in. cement concrete foundation—the minimum thickness—$3.48 per square yard; wood, including foundation, $3.08.

The concrete consists of six parts of Thames ballast, which is unscreened gravel and sand, to one of cement. Contracts usually include two years' free maintenance.

WOOD PAVEMENT ON STRAND SPREAD WITH CRUSHED GRAVEL—ONE-WAY TRAFFIC MAINTAINED

EXTREMELY HEAVY TRAFFIC, PRINCIPALLY MOTORBUS, NEAR PARLIAMENT SQUARE, LONDON

LAYING CEMENT-GROUTED STONE SURFACE ON ST. PANCRAS ROAD

REPAIR GANG PATCHING ASPHALT PAVEMENT IN WESTMINSTER

A supplementary contract is entered into for fifteen years' maintenance at a stated price per square yard of total area per year. In general these prices are: Wood pavement, 24 cents; asphalt, 42 cents. A repair price, including 9 in. of concrete, of $3 per square yard is charged against both asphalt and wood. The ordinary price of concrete is $1.32 per square yard. The maintenance cost of the wood pavement on Ludgate Hill is 36 cents per yard; on Gracechurch Street, 24 cents. The latter street was repaved this year with wood block under a new contract at the prices given for new work. The engineer estimates the average life of a wood pavement under heavy traffic at from 5 to 7 years. The foundation under Gracechurch Street had given seventeen years' service, but was reconstructed under the new contract 12 in. in thickness in order to have perfectly true surface and sufficient strength. In fact, the present policy is to put new concrete whenever a street is repaved.

For the granite pavements, which, although not laid on the most important streets, are of the type principally employed. Aberdeen granite is used. No tests or specification qualifications are called for, the material being purchased from known quarries, with the requisite dimensions. Blocks are laid on concrete foundation, the cost of this pavement being about $4.86 per yard, with an estimated possible life of from twenty to twenty-five years. A cement or bituminous filler is used, according to circumstances, the second being more often chosen. Contractors on repaving work pay about the following prices for labor: Common labor, 14 cents per hour; concrete gangs, 16 cents; wood pavers, 20 cents; stone dressers, 24 cents.

One of the activities of the city engineer's office consists in the improvement of the old narrow and irregular streets. For example, Fleet Street, part of one of the two main east-and-west traffic lines and probably for two thousand years the main line of traffic out of the city, is gradually being widened, to accommodate the constantly increasing traffic better, by the removal of a strip on the south side of the street as rapidly as the corporation can settle the claims of various property owners, either by purchase or through the courts.

Throughout the greater city maintenance work is usually promptly and well done, whether by contract or by the organization in control, and in the better portions of the city no cases were observed of neglected and badly worn pavements. In the outlying districts, however, particularly on the south side of the Thames, where a large area of hard wood was laid some years ago, a number of badly worn streets were seen.

WOOD PAVEMENTS IN WESTMINSTER

This is conspicuously not the case in the borough of Westminster. Here are about 100 mi. of paved streets within 4 sq. mi., an area including many Government buildings, the fashionable shopping and club district, Buckingham Palace and the wealthier residence region, as well as the large retail business section along Victoria Street leading to the Victoria Station. Practically every type of city street is represented within its limits, including quiet residential streets surfaced with macadam; a large amount of asphalt, on such heavy-traffic streets as Victoria Street, as well as in the narrow and poorer regions to the south of it; and an extensive area of soft-wood pavements on the principal thoroughfares. The last are probably the finest pavements in the world. Particularly good is that on Parliament Street and Whitehall from Parliament Square to Trafalgar Square. It carries a heavy traffic, principally motor omnibuses and other motor vehicles. Having less traffic but a very extensive one of pleasure vehicles of all classes is the Mall, extending from the Admiralty Arch at Charing Cross to Buckingham Palace. This is also wood block on concrete foundation and presents the nearest approach to a perfect street surface observed anywhere. Possibly the densest traffic within its limits is that along the Strand, which takes not only the vehicles coming from the south but also the heavy traffic of motor omnibuses and taxicabs which enter from the west and northwest. In fact, this street is the main thoroughfare into the city, as well as to Charing Cross Station.

The wood pavements have a life of about ten years under heavy traffic. After a service of this length the Strand, which appeared in the early part of the summer of 1913 to be in fair condition, was repaved in September of that year, half the street being laid at a time and the old concrete foundation left in place but resurfaced to a higher crown, as there had apparently been some settlement. The old blocks, which had originally been 5 in. in thickness, showed from 1 to 2 in. or even 2½ in. wear; but this had been comparatively uniform, the maintenance contractor having had a force continually at work making small repairs, even down to the removal of one block. This practice is being carried on throughout all the wood paved streets, on which small paving gangs can be seen at work almost any day. The work is done in leisurely fashion, as are the restoration of street openings and the work of repaving, measured by our standards; but it is careful and thorough.

GENERAL COMPARISONS

Surveying the city as a whole, London's best and most important streets and those which have its busiest traffic are surfaced with soft wood or asphalt. Granite blocks are usually employed in the warehouse districts, around the docks and railway freight terminals, and wherever there is a large amount of horse-drawn heavy trucking such as New York has. Asphalt and wood are also laid in the better retail shopping streets and the high-class residence districts. But to a large extent residence streets, including some of the best class and the majority of the middle class and poorer districts, are macadamized, sometimes with a tar macadam or tarred surface, but to a great extent with ordinary waterbound macadam. These residence streets differ from those in Manhattan in the generally lower height of buildings and greater proportionate width between building lines. Door yards and shade trees are frequently to be observed.

With the exception of one or two prominent intersections, such as Oxford Circus, Oxford Street and Tottenham Court Road, which are paved with dressed granite block at a cost varying from $6 to $10 per square yard, there are no granite streets equal to the best in Manhattan. But the average is probably better than the average here. Piccadilly Circus, at which point is the intersection of five important streets on a grade, has a combination pavement of alternate lines of hard and soft wood blocks to combine durability with absence of slipperiness. It seems to serve its purpose well.

As a rule, the soft wood pavements, constructed of a softer wood than ours and liberally sprinkled with crushed stone, have a gritty, smooth wearing surface suitable for horse traffic up to a considerable grade; while the asphalt, which, with the exception of the Thames embankment, is usually the natural rock asphalt, is very hard and slippery. On all of the streets the curbs are constructed with heavy granite, having usually a vertical, though sometimes a beveled, face, and the corners at intersections are of long radius.

Particularly to be noted as explaining some points of superiority in the London streets is the better work done in cleaning. Careful attention to this matter is given, not only on the prominent streets, as with us, but equally on the minor thoroughfares and side streets. The surfaces of smooth pavements are not permitted to become covered with dust which the first rain will turn into a muddy, slippery coating, and the more important thoroughfares are washed down and squeegeed every night.

The accompanying table gives the total mileage of publicly maintained streets and the mileage per square mile of area for each borough, as well as the expenditures in 1910 for maintenance and repair, cleaning and sprinkling. Of the total expenditure, $6,800,247.64, $3,203,060.12 is charged to maintenance and repair. Toward this cost $495,615.28 was received—$364,495.14 from companies and private persons for the reinstatement of roads, streets and paths broken up, $10,735.74 from the London County Council, $11,173.14 from other local authorities and $109,211.26 from other sources.

TOTAL MILEAGE OF AND EXPENDITURES ON LONDON STREETS IN 1910

	Length in miles	Miles per square mile	Expenditures	Per-mile expenditures
City of London.	48.5	46.1	$482,102.28	$9,939.70
Battersea	72.4	21.5	214,889.76	2,969.46
Bermondsey ...	69.0	29.4	154,645.20	2,240.46
Bethnal Green.	40.3	34.0	86,342.76	2,143.26
Camberwell ...	118.0	16.9	240,011.10	2,040.34
Chelsea	34.7	33.7	118,749.24	3,421.44
Deptford	50.5	20.7	75,310.56	1,492.02
Finsbury	38.0	41.3	106,788.78	2,809.08
Fulham	62.1	23.3	122,462.28	1,973.16
Greenwich	61.9	10.3	107,717.04	1,639.88
Hackney	106.5	20.7	232,386.18	2,191.86
Hammersmith .	52.3	14.6	97,034.76	1,756.52
Hampstead	62.0	17.5	176,505.48	2,847.96
Holborn	27.1	41.2	138,053.16	5,287.68
Islington	124.0	25.7	289,165.14	2,332.80
Kensington	91.0	24.4	282,212.58	3,168.72
Lambeth	151.4	23.7	400,687.56	2,648.70
Lewisham	120.0	10.9	229,426.02	1,909.98
Paddington	59.9	28.3	258,741.54	4,320.54
Poplar	64.3	17.7	161,065.26	2,502.90
St. Marylebone.	60.0	26.1	335,655.90	5,593.86
St. Pancras	86.0	20.4	351,645.30	4,092.12
Shoreditch	43.0	41.8	130,306.32	3,032.64
Southwark	65.0	36.8	303,997.86	4,680.18
Stepney	91.4	33.1	385,524.36	4,218.48
Stoke Newington	26.1	19.3	53,478.58	2,050.92
Wandsworth ...	184.0	12.9	393,596.82	2,138.40
Westminster ...	99.0	25.3	687,578.22	6,944.94
Woolwich	76.6	5.9	178,167.60	2,454.30
Total	2,184.0	....	$6,800,247.64	....
Average	....	18.7	....	$3,120.00

TRAFFIC REGULATION AND STREET CLEANING

Street refuges or safety isles are much employed where the width of the street will permit the division of traffic into two lines. Use is frequently made of these for installation of a line of lighting poles down the center of the street. The establishment of cabstands between them and the consequent avoidance of a line of waiting cabs along the curb are also made possible. There are fewer obstructions above the surface along the sidewalk than with us. Fire-hydrants are placed in recesses below the footwalk, under covers, and their location is shown by reference plates on adjacent walls or trees. Similar plates are also used to locate valve boxes or manholes in the footwalk. Instead of brushing street sweepings into sewer inlets, recess boxes are provided along the curb below the footway. From these they are subsequently removed by wagon.

Sewer inlets are made smaller and provided at more frequent intervals than here. Instead of having large catchbasins with vertical entrances at the intersecting corners, thus involving a running stream of water across the footpath, horizontal grated inlets are provided in the gutter, away from the corners, and these are seldom more than 100 or 200 ft. apart. This practice does away with the necessity for deep gutters, but in some cases it appears to be carried to too great an extreme, as where the curbs are not high enough to prevent vehicles running on the sidewalk. Ornamental sandboxes are provided frequently on the curb line, from which the street cleaners get material for sanding slippery pavements.

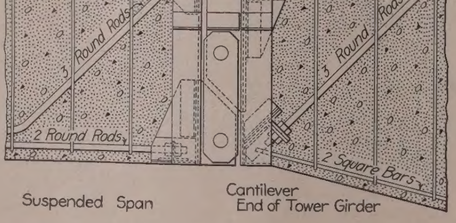
Tramway construction is very much like that of the street railways in New York. In the central portion of the city the center-slot system is used, but there appears to be less necessity for access to the current rails, as handhole boxes are less frequently used than with us. The covers are usually recessed and filled with paving blocks similar to the remainder of the street, so that an ordinary inspection does not show the boxes, and no covers are in evidence. The tie rods are spaced farther apart and are more accurately placed. In the suburban districts the overhead trolley system obtains. For both systems the same type of double-deck closed car is employed. The tram rails are similar in section to those used in New York, but lighter and of less depth. The maintenance of street-railway pavement in all cases appeared good.

New Type of Viaduct

SUSPENDED spans alternate between sets of two cantilever towers in the new 8217-ft. Colfax-Larimer Street Viaduct, in Denver, Colo., on which construction has recently started. This form of articulated slab-and-girder construction, which provides for settlement as well as expansion and contraction, was first attempted by H. S. Crocker, engineer for the city of Denver and the tramway and three railroads interested, at Salt Lake City on a much shorter structure. Economy for the Denver viaduct, which varies in width from 48½ ft. to 68 ft. and comprises 185 concrete bents from 30 to 55 ft. in length, is indicated by the fact that the contract prices will make the cost per horizontal square foot considerably less than $2.

At the wide portion near the long sharp intersection of Colfax and Larimer Streets, there are four lines of girders, the central slab being supported from the cantilever overhang of the outside slabs.

In design the columns are usually spaced on 40-ft. centers longitudinally, four columns supporting girders with a 20-ft. overhang at each end.



DETAILS OF NEW ARTICULATED CONSTRUCTION

Assisting Mr. Crocker in working up the designs for both Denver and Salt Lake viaducts was I. O. Thorly, office engineer. J. W. Cerny is resident engineer.

Filling an Abandoned Tunnel in Chicago with Concrete

AS foundations for the new building of Reid, Murdock & Company in Chicago were endangered by the existence of the abandoned cross-town water tunnel which passed under the property in a northeasterly direction, the city filled in 227 ft. of the tunnel with concrete to avoid accidents and damage suits. The piles for the new building extend 60 ft. below datum, and there was likelihood of their piercing the tunnel roof. Details are given by John Ericson, city engineer, in the 1913 annual report to the Board of Public Works.

To get into the tunnel a shaft was sunk 40 ft. north of the river dock line, but when down to El. —38, water broke into it, rising to El. —33, the elevation of the water in the tunnel. After removing the water with a No. 3 Emerson steam pump the shaft was completed, striking the tunnel a little east of the center line and 5 ft. north of a bulkhead, cutting off the river section. After pumping all water from the tunnel a timber bulkhead was placed on the west line of north Clark Street.

A pneumatic concrete placing machine was rigged to transport concrete above ground through 120 ft. of 8-in. pipe to the 60-ft. shaft, down the shaft and 150 ft. underground. After several trials, states the report, the pipe line was removed and the work of filling the tunnel was done by hand.

Once begun, the concrete work was continued uninterruptedly for eight days. The 4-ft. shaft was filled with sand. Labor cost $3,976.87; materials and supplies, $1,547.97; engineering and inspection, $359.87, making an average cost of $25.90 per linear foot for a 9-ft. diameter bore. The work was done under the immediate direction of F. A. Smith, assistant engineer.

UNIT COSTS OF CONSTRUCTION of a boiler house at the Lake View Pumping Station, Chicago, are given in the 1913 annual report of John Ericson, city engineer, as follows: Lumber and nails for each section of 26-ft., Wakefield yellow pine sheeting made up of three pieces of 2 x 12-in. planks with 3-in. tongue cost $5.09 and labor cost 81 cents. Excavation of 7893 cu. yd. of sand and earth by a ½-yd. Hayward clamshell bucket operated by an Orton & Steinbrenner locomotive crane was carried out at a unit cost of $1.02 per cubic yard. Old masonry, 656 cu. yd., was broken up with dynamite loaded into wagons and used for filling in the lake front at $3.35 per cubic yard. From twenty-eight caissons 4½, 5 and 5¼ ft. in diameter, 1011.5 cu. yd. of excavation were removed at $13.36 per cubic yard; 826.3 cu. yd. of 1:2:4 concrete placed at $5.57; an average cost per caisson, carried to hard pan to depths carying from —47.2 to — 41.3 was $646.83. Exclusive of caissons 234.8 cu. yd. of concrete cost $11.03 per cubic yard. This is high, says the report, because the work consisted of placing concrete in an old suction shaft, drainage sumps and conveyor trench in expensive forms, some of the concrete having to be deposited with buckets.

Electrolytic Sewage Treatment at Elmhurst

Criticism of Engineering Record's Editorial Comment on Travis Report and Reply Thereto—Professor Phelps Finds Electrolytic Process a Superfluous Feature of Treatment

AFTER the publication of the editorial in the Sept. 19 issue of this journal commenting on the report of the electrolytic sewage treatment tests at Elmhurst, L. I. (abstracted in the Sept. 12 issue) a letter criticizing the Engineering Record's attitude was received from C. P. Landreth, general manager of the Electrolytic Purification Company, of Philadelphia; his communication and an answer to it are given below. There is also a letter from Prof. Earle B. Phelps, of the U. S. Public Health Service, who makes this significant statement: "The results of this 'electrolytic' treatment can be accomplished without the electrolytic feature."

CRITICISM BY MR. LANDRETH

The letter from Mr. Landreth follows:

SIR: An analysis of the criticism on the chemical report on the method of treating sewage at Elmhurst, L. I., by the process which combines chemistry and electricity, in the Sept. 19 issue of the Engineering Record, page 315, shows so many wrong conclusions, based upon a partial knowledge only of the nature of the process that a review of the criticism seems proper. The article evidently is written by one who has not seen the plant in operation. [An abstract of the Elmhurst report was published in the Engineering Record of Sept. 12, page 292.]

(1) The report should be taken as a whole, not separated, with essential details omitted, otherwise many of the results accomplished are not evident, especially those due to the liberation of nascent oxygen, quick sedimentation, and the reasons for the conclusions reached. The large number of tests and chemical analyses made and included in the complete report all show that results are vastly different from those obtained by the addition of lime, iron and hypochlorite.

(2) The report in full clearly states that the apparatus used is not a sewage treating type. It was one originally designed for the treatment of water without gritty content, for softening purposes, modified to a degree by the addition of carbon plates, to carry out the chemical principles of the Landreth sewage treatment, and was loaned to the city for demonstrating the principles involved in this process.

(3) As to there being nothing new in the process except that the paddles are between the electrodes, this exception marks a difference in results obtainable by old electrolytic methods, and the use of electricity in conjunction with lime for the purpose of producing nascent oxygen and hastening precipitation is new. These and other features involved are considered sufficiently new to warrant the U. S. Patent Office to grant some fifty claims on process alone. A new feature ignored is the prevention of the rusting of electrodes by rendering them electro-negative when out of use, which accounts for their remaining bright as when put in.

As to the plates being of "iron composition," they are of plain, ordinary, mild steel, furnished by the Carnegie Steel Company, and purchased in the open market. They are therefore not liable to contain "other metals of even more strongly germicidal nature."

(4) The description of the method of flow of the sewage through this apparatus is incorrect, the description being taken from an old cut of a design abandoned, and does not have a path of 80 ft. to travel for the water, as the criticism states. The path of flow in fact is across eleven openings, each with a cross section of 10 x ⅜ in., a cross sectional area of 41¼ sq. in. The sewage has but five such paths to traverse and there is no appreciable loss of head in the apparatus, as is shown by the standard pressure gage attached for the purpose of such measurement. Apparatus intended for sewage treatment lies horizontally, on a level of the pipe line, and the sewage flows lengthwise of the apparatus, having an internal resistance of less than the inlet, which the full report states. Therefore, all criticism based upon the assumption of "high velocity through small holes and narrow spaces," and all statements relating to this feature in the criticism are erroneous, for they are based upon an incorrect assumption. The sewage would freely flow through the apparatus and the remarks on the energy required to pump are not pertinent.

(5) Tests were carefully made to determine the period of retention and were described in the report. It was found and so stated that the surface flow in the tank used (said tank being built by a carpenter and not an engineer) caused the sewage to leave the tank in 10 min. The immediate coagulation and precipitation apparent to all who visit the plant support this, and there is no 2.9 hr. of retention period as stated in the criticism.

(6) The full report stated that the bacterial examinations (made at the Bellevue Hospital as well as by Mr. Travis) showed a bacterial count of from 1,000,000 to 3,600,000 per cubic centimeter, and the quoting of one set of figures from the full report without the others does not indicate fairness. The criticism is incorrect in stating that analyses were made from the "effluent from each of these three parts of the equipment." The full report gives numerous tests on the results direct from the electrical process, and from the overflow from the first tank after 10 min. to 1 hour's retention (averaging about one-half hour). The intimation that the tests quoted were from the effluent of the big tank, trying to involve this retention as part of the process, shows either a deliberate intention to discredit, or a careless perusal of the report.

(7) The criticism infers that 50 per cent reduction of soluble oxygen occurred after the first sedimentation from that in sewage entering treatment, though these two tests are shown by the full report to be an admitted error due to the interference of hydrogen in the determination of the soluble oxygen. All other tests showed an increase.

(8) As to the "single stability test," the full report states that the effluent was invariably non-putrescible, and details are given of only one test, which included the sewage in the storage tank, a test most severe. The storage tank was not a part of the process, and is so stated. Dissolved oxygen tests on this storage and nitrite tests, all of which are given complete in the full report, have been entirely ignored by the critic.

(9) It is suggested that the best method "to determine, if possible, by what means the results have been brought about," could be best accomplished by a trip to the plant and observing the actual conditions, rather than a theoretical consideration of a method of treatment on which there are no published data, but which is protected by over fifty process claims allowed by the U. S. Patent Office. Criticisms based on theory, and not on fact, have no standing.

(10) As to the current distribution on the carbon and iron: The critic has overlooked the fact that the electrical circuit is divided. In this case the circuit was so divided that 18 amp were on the carbon and 2 amp seriesed eight times, or an ampere efficiency of 16 amp on the iron for the production of nascent oxygen by the breaking up of calcium hydroxide introduced, to form water and nascent oxygen at the positive pole, this reaction being cyclic.

(11) Only one test was made at 30 amp and is mentioned in the report. The tests were operated continuously at from 18 to 20 amp with this one exception, as the full report states. The one test was made to see if it would be of any increased benefit, and the results were reported. Mr. Travis' report is full, clean cut and honest.

(12) As to the increase in iron, it was clearly stated in the full report that the apparatus used is not for sewage treatment, there being no provision for the sedimentation of the sand as in the machine intended for sewage, and the iron found is caused by the grinding away of the plates under the paddles by means of the sand in the sewage. Considerable sand passed through, due to the method of pumping from the bottom of the receiving well. Provision is made in the sewage type for this sand and for its discharge. Such iron is finely divided and has no precipitating value. If the current is beyond the requirements of the free alkali, then some iron will be electrolytically decomposed, and its presence indicates that there is a waste of current and a waste of metal, which is not necessary.

(13) The statement, "a theoretical electrolytic solution of iron under the conditions obtaining" is well put, for it is a theoretical consideration only. Under the conditions of operation the theory cannot stand. The critic evidently overlooked the effect of an electric current on an alkaline solution and the laws governing such. The statement that "there is an electro-chemical production of 5.2 parts of available chlorine at the iron electrodes alone" is surprising. Available chlorine is chlorine which can be used for the purpose needed, yet he speaks of an iron salt being formed. Iron electrodes in a salt solution produce no available chlorine. The chlorine, after dissolving the iron, is attacked by the sodium, reforming sodium chloride. Therefore, carbon is used for hypochlorite production. The theoretical conclusions, therefore, do not hold.

(14) As to comparison at Worcester, Worcester has soft water and comparisons are not proper. The reduction in hardness in the report is not based upon analysis of the city water, but is based upon the hard-

ness of the sewage as received and delivered from the process. A number of analyses to determine the free lime in the storage tank showed a maximum amount of 20.26 parts per million of caustic lime expressed as calcium oxide, and is so stated in the full report. Worcester sewage contains iron and copper salts which produce coagulation by neutralization with lime. It is not normal sewage.

The statement that the "sewage has already been softened by soap" is misleading, for the effect of the alkali of the soap would be more than counteracted by the acidity of the sewage, both from its contents and the carbonic acid due to bacterial decomposition and rain water. The soap consuming tests were made on the sewage as received, and not on a theoretical basis. For this reason statements concerning the double quantities used are without a basis of fact.

(15) It is not "obvious" that the electrolytic treatment "comprises essentially the production of chlorine or hypochlorite and the solution of iron and possibly other metals of even more strongly germicidal nature." Hypochlorite is produced from sodium chloride in the sewage by the carbon electrodes, and they are used for this purpose. There can be no liberation of available chlorine from the iron electrodes, because of a well known principle of electro-chemistry. The free alkali is broken up by the current, and forms nascent oxygen at the positive pole without possible attack on the electrodes. (Those who think iron rust is caused by oxygen are referred to Cushings' exhaustive treatise on this subject.) It is the OH ion that appears at the positive electrode in this process, and it not being an attacking ion, unites with another OH ion in a secondary reaction to form H_2O plus oxygen in a nascent condition. All stimulus caused to chemical reaction by ionization hastened by the electric current is overlooked in the criticism, but is emphasized in the full report.

(16) The reference to "colloiders" hardly warrants comment, as it is a misprint, and clearly colloids is meant. It is well known by scientists that colloids upon contacting with electrodes under the influence of direct current give up their electric charges and cease to be colloidal, which term implies the carrying of an electric charge, which tends to keep them in suspension.

(17) As to capital investment and sludge treatment: These are strictly engineering questions and have been reported on at length by Elmer W. Firth, engineer of maintenance, Borough of Queens. It is easier to dispose of sludge which is without odor, without free grease, and easily discharged from the sedimentation basin, than to dispose of the noxious sludge produced by the usual methods. By the new process the sludge is completely converted into earthy material, without noxious odors, and these facts are clearly apparent from the full report.

(18) Cost figures given were on a basis of this small experimental apparatus, and comparable results in the use in a large way are not just, for even your critic states that small scale production cannot compete with the large scale operation. It is to be remembered that all chlorine is now produced by electrolytic methods, and comparisons with the cost of hypochlorite on a large scale production are not just nor fair. The apparatus for sewage treatment in a large way produces nascent oxygen at a lower cost than that obtained from hypochlorite, giving the same effect.

The critic is invited and challenged to make the comparisons suggested, with the same retention period of flow as exists at Elmhurst, providing the tests are made in the presence of competent electro-chemists from any standard laboratory in New York, and in the presence of competent witnesses. Thus the results will be recorded and support Mr. Travis and the competent engineers who have investigated this process in person. Others are invited to reserve criticism until full reports are read, and a knowledge of the operation of the plant is had or witnessed.

C. P. LANDRETH,
General Manager, Electrolytic Purification Company.
Philadelphia.

REPLY TO CRITICISM

[Most of the objections cited in Mr. Landreth's letter are criticisms of Mr. Travis' report. It was necessary to assume that this report, sent to the Engineering Record, unsolicited, by the secretary to the President of the Borough of Queens, New York City, was official and correct, and this journal assumes no responsibility, of course, for any incorrect statements made therein. Mr. Landreth also makes the point that the summary of the report published formed the basis of the criticism, whereas the full report to which he refers so frequently was thoroughly consulted and a reconsideration of the facts and figures given in that report does not indicate that any essential matter has been overlooked.

As the report does not show results from the mere addition of lime, iron and hypochlorite it is not evident that Mr. Landreth's results are "vastly different" as he claims. Reference to the experiment cited in the letter from Earle B. Phelps, professor of chemistry, U. S. Public Health Service, printed below, indicates that these results are not materially different.

A statement of the actual loss of head through the apparatus would be of much greater value to an engineer than Mr. Landreth's statement that "there is no appreciable loss of head."

The bacteriological results cited and to which Mr. Landreth takes exception are not as he states, "one set of figures," but give the actual range from maximum to minimum for all figures reported and give also Mr. Travis' actual calculation of the percentage of improvement. It is difficult to see how a fairer statement could be adopted.

The time of passage through the sedimentation tank was calculated in the usual form of average time of passage by dividing the total capacity of the tank by the rate of flow. It is well known that any tests made with dyestuffs give entirely erroneous results unless made in a much more careful and scientific manner than those reported by Mr. Travis. The first appearance of dyestuff through such a tank is in no sense a measure of the average time of passage. The fact must not be overlooked that in order to get his assumed 10-min. sedimentation period an actual storage capacity of 2.9 hr. sedimentation period had to be provided.

Mr. Travis definitely states that analyses were made from the effluents from each of the three parts of the equipment and gives results of such analyses. No intimation is made in the editorial that the tests were from the effluent of the big tank, each figure cited being definitely connected with the particular point in the system to which the sample was taken. As Mr. Travis' report gives results from all of the three separate subdivisions of the process, use was made of all three sets of figures. It is not true, according to accepted chemical views, that the presence of hydrogen interferes with the determination of dissolved oxygen.

Mr. Landreth objects to the inclusion of the large storage tank as a part of the process yet complains that tests of the effluent from this tank were entirely ignored.

The division of the electric current between the two sets of electrodes, which Mr. Landreth states was overlooked, was, in fact, correctly stated in the editorial.

Mr. Landreth's statement in paragraph (13) that, "the chlorine after dissolving the iron is attacked by the sodium, reforming sodium chloride," is illuminating in view of his claim that chlorine is not formed and that iron is not dissolved. It would be interesting to inquire as to the origin of the sodium referred to. Current electro-chemical views of the reaction call for an initial production of ferric chloride which, for the purposes of disinfection, is just as truly "available chlorine" as is chlorine itself, or hypochlorite. The amount of "available chlorine" produced by electrolytic action in an alkaline salt solution is not conditioned by the chemical nature of the electrode, neither is there any electro-chemical basis for the assumption that iron is not dissolved electrolytically in an alkaline solution.

Mr. Landreth states that the hardness determinations were not based upon analyses of the city water, which is contrary to Mr. Travis' statement that such was the case. It is a new thought in water chemistry that carbonic acid and rain water may counteract the effect of alkali and soap in the softening of a hard water. The formation of nascent oxygen in the presence of alkaline chloride solution is an electro-chemical impossibility.

The reference to "colloiders" is not a misprint, as Mr. Landreth claims and as he would recognize were he familiar with sewage literature.

It is agreed that cost figures upon this small installation are hardly significant, but as Mr. Travis' optimistic statements were based upon a citation of cost and as cost is the essential matter in any process of sewage treatment which may claim advantage over existing methods, the editorial in question necessarily dealt with the cost figures cited.—EDITOR.]

PROFESSOR PHELPS' FINDINGS

The following letter received by the Engineering Record after the publication of the editorial in the issue of Sept. 19 is significant:

SIR: After reading your editorial account of the discussion of the sewage treatment at Elmhurst, I asked C. P. Rhynus, of this laboratory, to make the experiment suggested by you upon Washington sewage. Mr. Rhynus had recently seen the Elmhurst plant in operation and was therefore in position to compare the results of this experiment with the actual results obtained at Elmhurst.

A sample of Washington sewage, taken at the pumping station, is examined at this laboratory daily. For this special experiment a specimen of sewage was treated with lime, copperas and bleaching powder in the proportions, 1600, 81 and 125 lb. per million gallons respectively. The bleaching powder gave 4.74 parts per million of available chlorine. It was equivalent, therefore, to 110 lb. per million gallons of commercial 36 per cent bleach. The mixture was shaken vigorously for a few minutes and allowed to settle for 3 hr. There was almost perfect sedimentation in a very short time with practically complete removal of color and turbidity at the end of the 3-hr. period. Stability tests showed 100 per cent stability. Bacteriological tests showed a reduction from 1,350,000 in the crude sewage to 25 in the clarified sewage. These were on the basis of 48-hr. counts at 37 deg.

Mr. Rhynus expressed the opinion that the coagulated sewage at Elmhurst formed somewhat larger flakes and settled somewhat more rapidly, but that in other respects this straight chemical treatment was apparently identical with the Elmhurst treatment. It seems, therefore, that except for the slight additional advantage of a vigorous mechanical agitation which is a well-known coagulating force, the results of this "electrolytic" treatment can be accomplished without the electrolytic feature.

EARLE B. PHELPS,
Professor of Chemistry, Hygienic Laboratory, U. S. Public Health Service.
Washington, D. C.

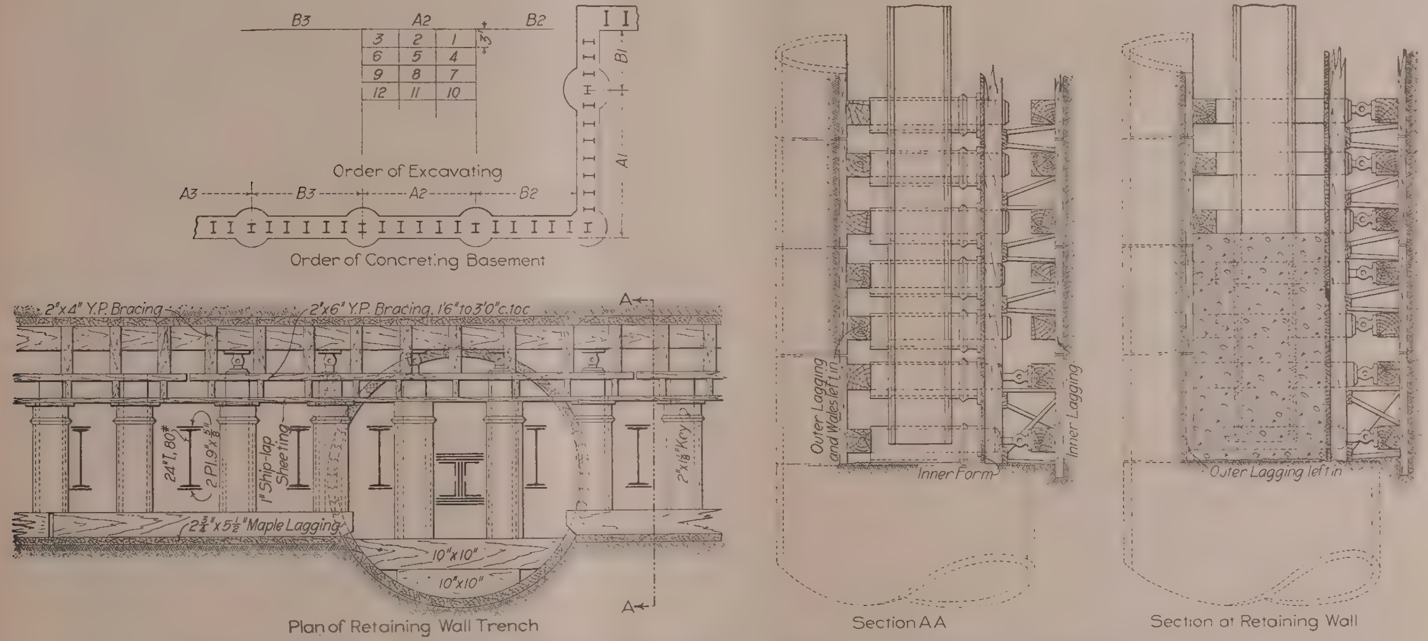
SEDIMENTATION BASINS at the Torresdale filters in Philadelphia are recommended in the 1913 annual report of Carleton E. Davis, chief of the Bureau of Water. The filters, it is stated, have not fully recovered from the severe strain caused by the unusual turbidity in the Delaware River in the spring of 1912. This situation emphasizes the need of preliminary sedimentation at this plant to permit it to cope successfully with peak loads. To a greater or less degree the turbidity of the Delaware reaches a point once or twice each year beyond the removal capacity of the plant. The damage to the filters at such times, Mr. Davis states, requires weeks and sometimes months to overcome, with the result that the plant is on the constant verge of breaking down under the loads.

Constructing Sub-Basement Walls Continuously in a Chicago Building

Concrete Reinforced with Rods and I-Beams Is Deposited without Horizontal Joints in Full-Depth Trench before Removal of Braces

BY boxing in the cross bracing between walls supporting the trench lagging reinforced-concrete sub-basement walls extending 50 ft. below the sidewalk were placed at one pouring under the Lumber Exchange office building in Chicago. This sixteen-story steel frame structure with floors of terra-cotta arches will have granite trim at the lower levels, and brick walls with terra-cotta trim above. It occupies corner property, 101 x 135 ft. in plan, at Madison and LaSalle Streets, and is supported on circular concrete caissons extending 105 ft. through dry clay to bed rock. Unusually heavy surcharged loads imposed by the surrounding buildings made the foundation pressures exceptionally large—in fact, they are estimated by the engineers to be greater than any hitherto encountered in Chicago. In the same block to the south is the sixteen-story Y. M. C. A. building resting on an integral floating foundation; to the east is a three-story building on simple spread foundations, while across the street to the north is the thirteen-story Tacoma building, also on a grillage. The other two corners, occupied by the LaSalle Hotel and the Otis buildings, rest on caissons. Due to the heavy pressures exerted by these floating structures and the tendency of the clay to flow, extreme care and ingenuity had to be exercised to insure the integrity during construction of the adjacent structures as well as that of the deep trenches for the second and third basement walls.

In order of construction the caissons were excavated first by the usual well method employed in Chicago, the material being raised to the surface by winches, several of which were driven continuously by an endless wire rope from a single 25-hp engine. The material was then disposed of through a chute to the Illinois Tunnel. Following the filling of the wells with concrete to the lower sub-basement floor level came the erection of the steel columns in the wells permitting the continuation of the work on the building above ground level during completion of the basement work.



Order of Excavating

Order of Concreting Basement

Plan of Retaining Wall Trench

Section AA

Section at Retaining Wall

DETAILS OF METHODS OF BRACING SUB-BASEMENT WALL TRENCH, AND ORDER OF PROSECUTION OF WORK

WALL CONSTRUCTION

Alternate sections of the deep basement walls between columns were excavated in three portions 6 ft. deep, each portion being braced before proceeding to the second. Only three or four hours at the most were allowed between completing the excavation and placing the 3 x 6-in. vertical lagging, 8 x 8-in. wales, and 8 x 8-in. "drums" or cross braces with screw jacks in the ends. The braces were placed symmetrically one above the other, from 1½ to 2 ft. apart vertically and 3 ft. horizontally. The same spacing was invariably used, so that the superintendent could see from the top of the trench that everything was in place. Six inches of concrete were deposited on the bottom of the trench as a working floor from which to erect the forms for the full height of the wall. The drums were then boxed in and the trench was concreted in one operation.

BOXING IN THE DRUMS

By former methods concrete was placed in sections, the bracing being removed after the concrete was brought up to the underside of the drums and allowed to set twelve hours, thus subjecting the green mixture to the full horizontal pressure of the flowing clay long before it had a chance to harden. In the system now employed the braces are boxed in and left in place until the concrete has set and the pressure can be shifted to the floors. The back lagging constitutes the back form and with its supporting wales is left in place. The trench is made 2 ft. wider than the wall so as to obtain a smooth face and exclude the wales on the inside. When the braces have been removed, dry concrete is rammed into the holes left by the boxes, being held by notches left by keys nailed on the boxes.

Reinforcing is placed in the wall to carry the load after the excavation has been made. It consists of from 18-in. to 24-in. I-beams 36 ft. long, placed vertically for the heavier loads, which are carried up or down and distributed into the floors. To place these I-beams it is necessary to leave out the tile work in the first and second floors above the street level immediately over the basement walls. This impedes progress to a certain extent, and wherever possible, rod reinforcement is used.

To preclude any chance of settlement the basement walls are supported by small caissons which are extended to hardpan by means of the ordinary well method from the bottom of the trench excavation.

Floors are placed as the excavation proceeds, but bracing to the columns in horizontal bents about 5 ft. apart is carried clear across the basement to the opposite side, thus relieving any tendency to bend the columns. Where irregularities in column spacing do not permit a continuous line of bracing, diagonals are employed either in a horizontal or a vertical plane. All braces precede excavation, which is carried out in 5-ft. lifts.

Advantages of the newer method, as given by the architects, are speed, elimination of rod reinforcement in trenches and resistance of earth pressure by drums until the concrete has thoroughly set. The wall is a continuous mass of concrete. By the old method the walls are full of horizontal joints close together. Arches in floors above must be left out to allow the placing of steel beam reinforcement, as it is not so satisfactory to use steel reinforcement, due to the large number of horizontal joints and the difficulty of caring for shear. The most serious disadvantage of the former method is that the earth pressure must be resisted by concrete, so green that earth movement often takes place, making progress slow.

HANDLING ADJACENT FOUNDATIONS

As the Y. M. C. A. foundation extends 15 ft. beyond the lot line it was necessary, in driving the wells for the south tier of caissons, to pierce the old matt and shore the walls and columns of the Y. M. C. A. building. The columns were shored by bolting brackets on them and jacking up from the footings. The old foundation was disconnected from the new caissons by a sand filling. This is essential to prevent unequal upward resistance on the floating foundation.

The west wall of the three-story building adjacent to the new work was carried during construction of the caissons on a needle-beam grillage of 24-in. I-beams spaced about 2 ft. apart. New brick walls were built up between the beams and wedges placed before slacking off the jacks under the needles. The supporting concrete wall rests on the caissons. It is 18 ft. deep and was figured as an arch to carry the wall load to the caissons. The walls and columns in this building are not connected, but are simply spread foundations on the clay, extending about 15 ft. below the sidewalk.

Holabird & Roche are the architects and the George A. Fuller Company is the general contractor for the building. The steel, which was erected by the Oscar Daniels Company, was furnished by the American Bridge Company. The Ruud-Neilsen Company had the contract for the shoring.

Pipe Laying

Third Article of Series of Three Based on Extensive Studies of Costs and Methods of Sewer Trenching

By RICHARD T. DANA
Consulting Engineer, New York City

THE cost per linear foot of pipe laid depends upon the kind of pipe, involving its weight, size and mode of lowering into the trench, on the depth of trench and obstructions to lowering due to sheeting, etc., on the kind of joint, whether bitumen, lead or cement, and on the directorship of the foreman and the skill of the workmen. As in the case of sheeting, pipe laying requires skilful workmen. Men should be carefully trained to do this work and should then be kept at it.

FILLING JOINTS WITH BITUMEN

UNIT COSTS FOR SMALL PIPE

In Table 1 will be found unit costs and other data on 6, 8, 10 and 12-in. sanitary sewer pipe. This pipe was vitrified salt-glazed clay pipe, and had joints first calked with oakum and then filled with hot bitumen. Two or three lengths of pipe were joined together on the surface of the ground, the hub and spigot being first cleaned of any foreign substances by washing with a solution of bitumen dissolved in gasoline. The joints were next calked with oakum and then, with the pipes in an upright position, the joints were filled with melted bitumen. When the joints were cool and firm, a rope having a hook on one end was placed

TABLE 1—UNIT COSTS AND OTHER DATA FOR LAYING VITRIFIED SANITARY SEWER PIPE, SIZES 6, 8, 10 AND 12 IN.

No. Obs.	Unit cost, cents per lin. ft.	Cut, ft.	No. men	Size of pipe, in.	Equivalent 10-hr. performance, lin. ft.	Quantity per joint, lb.		Remarks
						Tar	Oakum	
				CASE 1				
1	2.7	6.5	5	6	310			
2	4.9	6.5	5	6	261			Sheeting
3	5.2	6.5	5	6	310			
Average	4.3	6.5	5	6	293.6			
				CASE 2				
1	4.0	6	5	8	424			
2	5.2	8	6	8	310	0.80	0.20	Sheeting
3	5.4	8	4	8	171	0.82	0.24	Sheeting
4	6.0	8.4	4	8	141			Sheeting
5	6.0	7	6	8	210			Sheeting
6	6.26	8	5	8	198	0.91	0.23	Sheeting
7	6.3	8.7	5	8	179			Sheeting
8	6.4	8	4	8	144	0.95	0.28	Sheeting
9	6.45	8	5	8	128	0.82	0.24	Sheeting
10	6.46	8	5	8	189	0.70	0.20	Sheeting
11	6.6	8	4	8	127			Sheeting
12	6.6	8	4	8	149	0.94	0.27	Sheeting
13	7.05	6.5	5	8	152			Sheeting
14	7.1	6	5	8	150			Sheeting
15	7.2	9	4	8	106	0.66	0.26	Sheeting
16	7.35	8	6	8	224	0.81	0.27	Sheeting
17	7.90	8	4	8	132	0.87	0.22	Sheeting
18	8.5	8	6	8	135	0.67	0.17	Sheeting
19	9.1	8	4	8	92	0.65	0.35	Sheeting
20	9.35	7	5	8	103			Sheeting
21	9.7	8	4	8	80	0.60	0.15	Sheeting
22	9.85	9	4	8	88	0.63	0.31	Sheeting
23	10.90	8	4	8	57	0.79	0.21	Sheeting
24	11.4	9	4	8	59	0.84	0.17	Sheeting
25	13.5	8	4	8	63			
Average	7.6	7.9	4.6	8	152.4	0.78	0.235	
				CASE 3				
1	5.7	9	3	10	210			Solid sheeting
2	7.5	10	3	10	136			Solid sheeting
3	7.8	10	4	10	160			Solid sheeting
4	9.1	8.5	4	10	136			Solid sheeting
Average	7.5	9.4	3.5	10	160.5			
				CASE 4				
1	5.4	8	5	12	189			Sheeting
2	5.7	7	5	12	228			Sheeting
3	6.0	8	5	12	178			Sheeting
4	6.4	8	5	12	207			Sheeting
5	7.4	7	5	12	152			Sheeting
6	8.0	10.5	5	12	132			Sheeting
7	8.1	7.5	5	12	137			Sheeting
8	8.7	15	4	12	63			Sheeting
9	9.4	7	5	12	110			Sheeting
10	10.2	8	4	12	71			Sheeting
11	10.8	10	5	12	83	1.72	0.69	Solid sheeting
12	11.5	11	5	12	77	1.56	0.62	Solid sheeting
13	11.6	13	5	12	60	1.43	0.44	Solid sheeting
14	11.9	10	5	12	74	0.96	0.19	Solid sheeting
15	12.0	17	4	12	52			Solid sheeting
16	12.4	10	5	12	67	1.34	0.54	Solid sheeting
17	13.0	12	5	12	66	1.00	0.25	Solid sheeting
18	13.7	10	5	12	62	1.59	0.54	Solid sheeting
19	13.75	13	4	12	64	0.87	0.22	Solid sheeting
20	13.80	10	5	12	60	0.83	0.17	Solid sheeting
21	14.4	14	6	12	90	1.13	0.45	Solid sheeting
22	16.0	13	5	12	52	2.38	0.71	Solid sheeting
23	16.3	13	5	12	50	1.18	0.35	Solid sheeting
24	17.6	13	4	12	35	1.54	0.31	Solid sheeting
Average	11.0	10.6	5	12	98.3	1.35	0.42	

Average widths of trench, 6-in. pipe, 30 in.; 8-in., 32 in.; 10-in., 36 in.; 12-in., 36 in.

In the above unit costs are included the cost of preparing pipe, laying, calking and tarring, and a proportion of the charges for foreman and waterboy.

TABLE 2—UNIT COSTS AND OTHER DATA FOR STORM DRAINS, SIZES 12, 15, 24 AND 36 IN.

No. Obs.	Unit cost, cents per lin. ft.	Cut, ft.	No. men	Size of pipe, in.*	Equivalent 10-hr. performance, lin. ft.	Per joint, lb. cement	Remarks
CASE 5							
1	2.8	6	4	12 C	300	3.33	No sheeting
2	2.9	7	4	12 C	263	3.80	No sheeting
3	3.2	5	3	12 V	220	2.8	No sheeting
4	3.4	6	4	12 C	240	4.18	No sheeting
5	3.4	6	4	12 C	261	2.61	No sheeting
6	3.52	5.5	3	12 V	198	1.98	No sheeting
7	3.6	6	3	12 V	250	4.1	No sheeting
8	3.7	6	4	12 C	250		No sheeting
9	3.7	5	3	12 V	232	4.76	No sheeting
10	3.8	5.7	4	12 C	240		Very little sheeting
11	3.8	5	3	12 V	232	4.66	No sheeting
12	3.9	6.5	2	12 V	130	4.18	No sheeting
13	4.6	6	3	12 V	152	3.58	No sheeting
14	4.7	6	3	12 V	149	3.78	No sheeting
15	5.27	7	5	12 C	190	3.54	No sheeting
16	6.70	6	4	12 C	120		No sheeting
17	8.2	6	4	12 C	125	2.00	No sheeting
Average	4.2	6.0	3.5	12	209	3.52	
CASE 6							
1	3.6	7	5	15 C	260		Sheeting
2	5.0	6	5	15 C	204	4.4	Sheeting
3	5.25	8	4	15 C	165	4.5	Sheeting
4	6.70	8	5	15 C	150	4.0	Sheeting
Average	5.14	7.25	5	15 C	194.7	4.3	
CASE 7							
1	6.35	7	5	24 C	157		Sheeting
2	6.80	7	6	24 C	162	1.85	Sheeting
3	6.90	7	5	24 C	144		Sheeting
4	7.85	7.25	5	24 C	131		Sheeting
5	8.35	7	7	24 C	162	2.46	Sheeting
6	9.1	9.5	6	24 C	126		Sheeting
7	9.4	8.5	6	24 C	122		Sheeting
8	12.0	12	5	24 C	81		Sheeting
9	12.3	8	4	24 C	75.5		Sheeting
10	13.2	6.5	5	24 C	75		Sheeting
†11	23.6	8	4	24 C	41		No sheeting
Average	9.2	8.0	5.4	24 C	123.5	2.15	
CASE 8						Mixing and placing concrete base, cents per lin. ft.	
1	9.8	9	4	36 V	86	11.5	Solid sheeting
2	12.9	9	4	36 V	77.5	17.9	Solid sheeting
3	16.9	9	5	36 V	68	21.2	Solid sheeting
4	18.1	9	5	36 V	56	18.9	Solid sheeting
5	20.0	9	4	36 V	64		Solid sheeting
Average	15.5	9	4		70	17.4	

*12 C = 12-in. circular concrete pipe.
12 V = 12-in. circular vitrified pipe.
15 C = 15-in. egg-shaped concrete pipe.
24 C = 24-in. egg-shaped concrete pipe.
36 V = 36-in. circular vitrified pipe.
†Left out of the averages.
Average widths of trench, 12-in. pipe, 36 in.; 15-in., 30 in.; 24-in., 42 in.; 36-in., 60 in.
In the above unit costs cementing the pipe joints is included with the laying, also a proportion of the charges for foreman and waterboy.

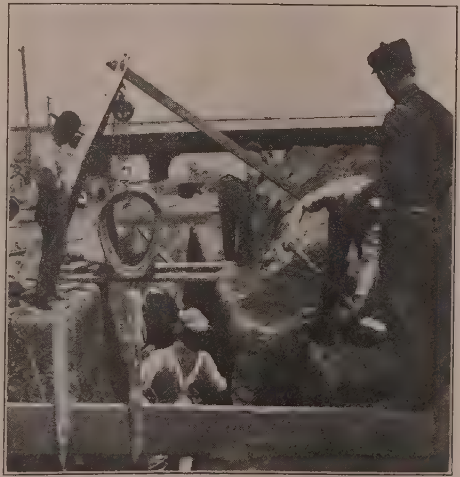
through the pipes and hooked to the lower edge, in which position the pipes were lowered. Another method of lowering was to pass a rope through the pipes so that both ends might be grasped by men on the surface and the pipes lowered horizontally. The lowering and, in fact, the laying were retarded greatly by the braces which held the sheeting, and also by the great depths of trench.

After a section was lowered into the trench and properly lined in both horizontal and vertical planes the joint was calked with oakum and filled with bitumen, using a "snake" in the same manner that a leaded joint is run. One man on top was in charge of jointing, and another man was responsible for supplying the men in the trench with hot tar, also assisting in lowering the pipe. When not so engaged he should assist the first man to prepare the pipe. A third man was needed to assist in lowering. In the trench one regular man and an assistant had charge of the jointing and alignment. When not so engaged they made grade for the next two lengths, using the material thus removed for backfill over the pipes last laid.

UNIT COSTS FOR LARGE PIPE

In Table 2 will be found unit costs and other data on storm-water sewer pipes, 12, 15, 24 and 36 in. in diameter. All joints were cemented after the pipe was lowered into the trench in single lengths. The 12-in. pipe was of circular section, some cement and some vitrified. Lowering was done by hand, using a rope passed through the length of the pipe.

The 15 and 24-in. pipe used in the work were made of cement and were egg-shaped. To lower these into the trench a tripod rigged with a differential block and tackle was used. The 36-in. pipe was vitrified and circular in section. A tripod and a block were also used here in lowering. The photograph below shows the apparatus in the act of lowering a section of the egg-shaped pipe.



LAYING EGG-SHAPED CEMENT PIPE

Elements of Value of a Public Utility

Joint Committee of Ohio Utilities Formulates Principles for Guidance in Making Appraisals as Required in That State

UNDER date of March 19, 1914, the Ohio Public Utilities Commission issued Order 176, requiring inventories and appraisals of the property of all public utilities in the State, and on April 25, 1914, issued a supplemental order on the same subject. The order calls for the reproduction cost new less depreciation method of valuation. At a meeting Aug. 14, 1914, of representatives of the various utilities in the State a committee consisting of officials of illuminating, telegraph, telephone and waterworks companies and suburban electric railways was appointed to formulate principles applicable to all utilities. The following notes are taken from the committee's report, just made public.

OUTLINE OF INVENTORY

In order to comply with Order 176 it is necessary that the inventory should show the following:

I. Reproduction cost new of:
  A. Preliminary work.
    1. Preliminary investigation.
    2. Organization of company.
    3. Cost of financing.
    4. Franchise.
  B. Physical plant, consisting of:
    1. Land.
    2. Rights-of-way and water rights.
    3. Buildings.
    4. Generating or pumping plant, exchange equipment, etc.
    5. Distribution and transmission systems, track, etc.
    6. Tools, teams, vehicles, etc.
    7. Furniture and fixtures.
    8. Working capital.
      (a) Cash and other quick assets.
      (b) Stores and supplies.
    9. Other items of physical property.
  C. Established business.
    1. Cost of organizing and training operating, selling and clerical forces.
    2. Cost of selling service.
    3. Any other costs of attaching business.
II. Any other elements of going value or good will.
III. All other elements of value.

The foregoing items are more specifically defined in succeeding paragraphs. Preliminary investigation, the report states, should date back to inception, but should exclude promoters' compensation, which should come under organization. Organization should cover promotion, incorporation and other legal expenses, and preparation of stock and bond issues and other documents. Discount on bonds, however, and expenses incident to negotiating loans should come under cost of financing. Only the amounts actually paid for franchises should be listed.

PHYSICAL PLANT

Under the heading "Land" should be given the original cost, including purchase price, condemnation costs, brokers' and attorneys' fees, surveying costs, recording fees, liens on the property, payments for damages to abutting property and cost of grading land when not done in connection with buildings. The date and conditions of acquisition should also be given. The value as of July 1, 1914, should be given for each parcel, with comparative figures for contiguous property, and the authority for such figures. Additional value by reason of present use should be recorded, consideration being given to (1) location with reference to center of distribution, (2) location with reference to transportation facilities, (3) suitability of property for future growth and (4) any other natural advantage, such as availability of supply of condensing water, etc.

The cost of reproduction of each building owned by the utility should include preliminary costs and the contractor's charge for reproducing the building. The latter should be based on one or more competent contractors' estimates, which should show quantities and unit prices and take into account proper allowances for delays due to strikes or other causes, contractor's profit and his costs to meet payments prior to final settlement according to the usual plan. In making his estimate the contractor should not omit those elements of cost which while not apparent in the finished building are necessarily incurred in connection with its construction. Among such items are demolition of old buildings, excavation, pumping, bracing, protection of streets and adjoining buildings, cost of estimate, traveling, insurance, bond, fees and permits, stair guards and lights, tests, protection of masonry and other work, temporary office, telephone, photographs, sheds, temporary toilets, temporary heat, temporary inclosures, watchmen, omissions and contingencies. Architects' and owners' supervision, unforeseen expenses not included in the contractor's estimate, and the cost of grading, sidewalks, fences, etc., in connection with the building are also elements of value.

The allowance for working capital should be sufficient to care for emergencies and contingencies as well as the ordinary expenses of operation.

UNIT COSTS

In estimating unit costs it should be remembered that plants are always constructed piecemeal, with consequent greater cost. The following elements, states the committee, enter into the cost of any unit: (1) Cost of unit f.o.b. point of supply, (2) cost of purchasing, (3) cost of inspection, (4) freight switching, expressage and cartage, (5) cost of unloading, (6) cost of preparing unit for use, (7) cost of hauling to point of use, whenever different from point of delivery, (8) shop, store-room or yard charges, (9) labor, (10) tools and appliances, (11) incidental material, (12) breakage, loss and waste, (13) construction superintendence, (14) employers' liability insurance and (15) public liability insurance.

Overhead costs should include legal expenses, administration and supervision, engineering, insurance, taxes and interest during reproduction, contingencies, and omissions and oversights.

Some of the elements of expense which enter into the cost of reproducing the business are as follows: (1) Organizing and training the operating force, (2) organizing the clerical force, (3) organizing and training the selling force, (4) securing customers, including expenses of solicitors, advertising, printing and free inducements, (5) commercial engineering, (6) printing forms, records, books, schedules and directories and (7) rent of offices.

Inasmuch as Order 176 requires that depreciation be shown, the report briefly explains the straight-line and the sinking-fund methods, but finds both inferior to actual inspection. Attention is called to the distinction between depreciation and depreciation reserve, the latter being a fund set aside in anticipation of the occurrence of depreciation. In the words of the report, "It is important to note that neither the amount in the depreciation fund nor the amount which ought to be in such fund is in any way a measure of the depreciation or loss of value which has already taken place, nor does it afford a measure of the rate at which depreciation or loss of serviceability will occur in the future."

The committee believes that depreciation in preliminary and overhead costs, if it exists at all, is so small that it is impracticable to compute it, and that the utilities are justified in ignoring it in making up their inventories.

In conclusion the committee points out that reproductive cost new less depreciation is not the only evidence of the value of a utility, and recommends that the following clause be inserted on the last sheet of the inventory above the signature:

"This inventory and appraisal has been made in an effort to comply in all respects with the commission's Order No. 176, by listing the items of property owned by this company and stating their reproductive cost new less depreciation. The company reserves the right, in any appropriate proceedings involving the value of said property or any part thereof, to offer any other or additional evidence of value."

Mill Creek Sewer System in St. Louis—A $3,000,000 Pressure Tunnel Project

Types of Section for Tunnel and Open Cut in Earth and Rock—Analysis of Arch—Concrete Requirements—Sheeting and Bracing—Part III

By W. W. HORNER and LELAND CHIVVIS
Principal Assistant Engineer Engineer of Constructions
St. Louis Sewer Department

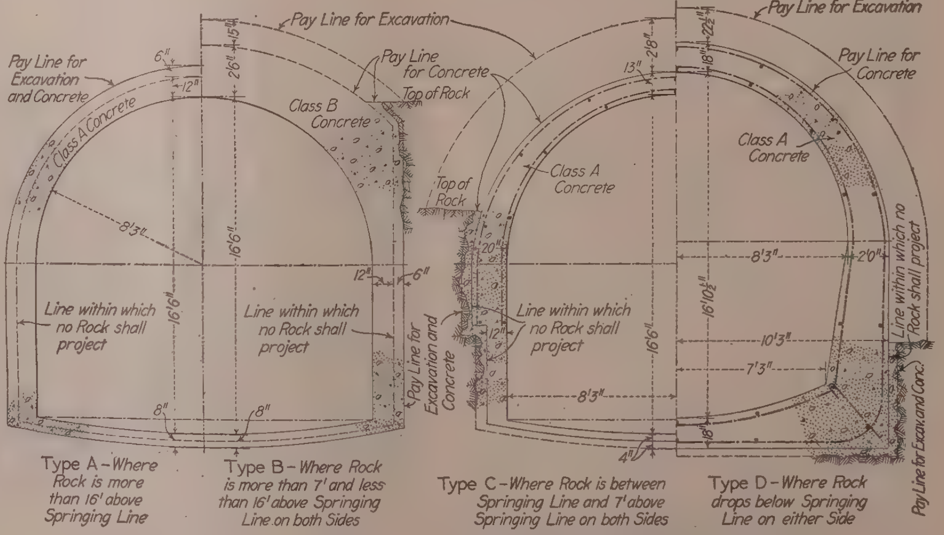
THE adoption of the route for the Mill Creek sewer and the establishment of a level flow line at El. —25, city datum, was described in Part II of this article last week.

In the detailed design of this work a careful scheme of construction was evolved and reasonable variations from it were considered. All details were planned for simplicity. The specifications cover the methods and details of work under any contingency which may reasonably be a possibility. The number of items for bidding and the quantities estimated are such that a reasonable bid on each item should enable the contractor to work at a fair profit under any condition that may arise.

During the early study of this route punch borings were made to locate the top of the rock; after the adoption of the line, contracts were let for diamond core drilling and a total of about sixty holes have been put down. The logs of the borings have been plotted on the contract plans as have also the rock elevations obtained from punch borings.

The sections for the tunnel are shown in the drawings. The hydraulic properties of the section are exceptionally good, but the choice of shape was influenced as much by other considerations. The semicircular arch is expected to give a maximum strength against faulty rock which does not show its weakness during the tunnel driving; the straight side walls and flat invert will certainly expedite the shooting operations, and the latter will allow a maximum width of flat track space in case it is desired to use a small air shovel for mucking. Of the sections, type A will be used for over 95 per cent of the tunnel length; type B may be used in faulty rock or where the top of the rock is near the crown of the tunnel; type C is for locations where the arch is partly in soft ground; type D is similar to the open cut section and may be used at the Eighth Street gap if the rock is found to be lower than spring line of the sewer.

Type A section is to be used only where the rock is self-supporting. As the stone is a medium limestone in mainly flat beds it seems very improbable that any great



Type A – Where Rock is more than 16' above Springing Line

Type B – Where Rock is more than 7' and less than 16' above Springing Line on both Sides

Type C – Where Rock is between Springing Line and 7' above Springing Line on both Sides

Type D – Where Rock drops below Springing Line on either Side

FIG. 1—VARIOUS TYPES OF TUNNEL SECTION FOR MILL CREEK SEWER

stress or pressure will be found. Special precautions will be taken to secure good drainage behind the lining and prevent the accumulation of any hydrostatic pressure. As this stone has fair weathering qualities and shows little tendency to slack or swell, the tunnel might have been left unlined for the greater portion of the length, and the possibility of leaving out part of the lining was actually considered. It was found, however, that the section, if left unlined, would have been slightly larger than the section within the excavation lines for type A. The danger and expense of working in the tunnel after it had been in service, the fact that it would be submerged by backwater from the river for several months in the year, the expense later of cleaning the rock to secure a bond with the lining, if it should ever become necessary, and the possibility of small falls of rock during a rain were all good arguments for placing the lining immediately.

In all these sections the pay lines have been fixed to make a reasonable allowance for overbreak. As is shown in the type A section the pay lines for both excavation and concrete are 18 in. outside the neat lines, except in the invert, while the required clearance line is 12 in. outside, an allowance of 6 in. In the bottom, the allowance is 4 in., both for excavation and concrete.

Class A concrete will be used for the tunnel lining, except where the massive type B section is required, in which case class B concrete will be substituted. Class A concrete contains fine aggregate amounting to one-half of the volume of the coarse aggregate, and for every 4½ cu. ft. of coarse aggregate the concrete in place will contain 94 lb. of cement. Class B concrete contains fine aggregate amounting to one-half of the volume of the coarse aggregate, and for every 6½ cu. ft. of coarse aggregate the concrete in place will contain 94 lb. of cement.

OPEN CUT SEWER

The arch for the open cut sewer in soft ground is shown in Fig. 2. This sewer differs in internal dimensions from the tunnel section only by the batter of the side walls. The invert of this section was lined with vitrified brick as a protection against possible acids in the gas company's waste which, with the dry weather flow of the old Rutger Street sewer entering at Sixth Street, is the only foul water introduced into the new sewer.

In the design of this arch the loading was taken as that due to an 18-ft. fill over the crown, plus an additional earth fill of 7 ft. as equivalent allowance for engine loads. This latter provision takes account of the fact that a number of tracks now cross the line and others may in future be constructed at any point. The arch was first designed for a 25-ft. fill, using the formulæ derived from Green's constants for the elastic arch. These formulæ are for the semicircular arch under vertical earth loads, with the least possible horizontal pressure acting on the arch and no horizontal pressure on the side walls. This loading can only occur under a fresh fill before settlement, but is one of the four critical conditions. Under this loading the formulæ give approximate values of the bending moment at each 10-deg. point on the arch and at the invert point. In practice it has been found that if the arch is dimensioned for moments at four of these points the resulting section will form an excellent basis for further analysis under other loads and by more accurate methods. The four formulæ in which M is the bending moment in foot-pounds are:

At crown, $M = + R^2(5.47 + 3.8F - 0.2R)$.

At 60-deg. point. $M = - R^2(5.76 + 3.30F - 0.7R)$.

At 90-deg. point, $M = + R^2(13.84 + 7.75F - 1.4R)$.

At invert, $M = + R^2(70 + 38.0F - 2.0R)$.

Crown thrust, in pounds, $H = + R(81 + 43F - 2.0R)$.

Vertical thrust in side wall, in pounds, $W = + R(200 + 108F - 21R)$.

R, the mean radius of the arch in feet = 9.25; F, the fill on the crown in feet, = 25. Substituting these values, the formulæ give:

$M_0 = + 8370$ ft.-lb.; $M_{60} = - 6800$ ft.-lb.; $M_{90} = + 16,500$ ft.-lb.; M (inv.) $= 85,000$ ft.-lb.; $H = 10,400$ lb.; $W = 25,000$ lb.

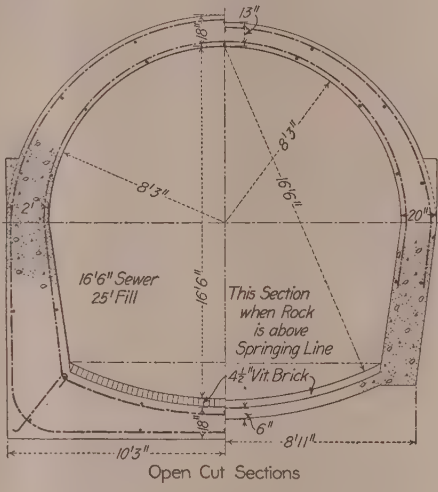


FIG. 2—SECTIONS FOR OPEN CUT

Using an allowable total working stress of 550 lb. in the concrete the thickness was first determined from the moments; the direct stress per square inch from thrusts was computed and deducted from the 550 lb., and a new thickness based on the moment and remaining working stress was calculated. By a series of trials the total thicknesses at the four points, including the 3-in. cover for the steel, were found to be, respectively, + 15, 14, 22 and 41 in. From experience with other arches it was known that the loading in which horizontal forces predominated would require increased thickness at the crown and 90-deg. points and that a more accurate design would permit of a reduction at the invert point. These values were arbitrarily changed to 18, 24 and 36 in. respectively. The moment at the 60-deg. point cannot be used to determine concrete dimensions as the thickness there is fixed by the dimensions at the crown and the 90-deg. point. For this trial design no use whatever is made of the moment at this point but in the final designs the critical moment for the 60-deg. point is used in connection with the predetermined thickness to compute working stresses and reverse reinforcement.

ANALYSIS OF SECTION

The sewer as determined above was analyzed for four conditions of loading all symmetrical about the vertical axis and for three conditions of fixture. These conditions are as follows:

Case 1—Arch fixed at invert point, full vertical load acting, minimum horizontal load above 90-deg. point.

Case 2—Arch fixed at invert point, full vertical load acting, horizontal pressure both above and below the 90-deg. point.

Case 3—Arch fixed at invert point, hydrostatic pressure of 100 lb. per cubic foot acting on whole arch above invert point.

Case 4—Whole sewer considered as an elastic bent beam fixed only in direction at the crown and middle of invert, hydrostatic pressure as above and upward pressure on the invert.

Case 5—Arch fixed at the 90-deg. point, whole vertical, and minimum horizontal, loads acting above that point.

Case 6—Arch fixed at the 90-deg. point, hydrostatic pressure as in Case 3, acting above the 90-deg. point.

In cases 1, 2 and 3 the sewer is considered to rest on rock or hard ground. In case 4 it is on plastic soil. In cases 5 and 6 it is imbedded in rock up to the 90-deg. point. The loading in cases 1 and 5 is considered to be hard earth dumped on and not yet compacted; in case 1 it is considered that a void occurs outside the side walls due to such cause as the withdrawal of piling. In case 1 the sewer is assumed to have been constructed against the side of the trench, allowing horizontal forces to come into action immediately. In cases 3, 4 and 6 the fill is supposed to be saturated.

This sewer had been designed for a width of 17½ ft. when a last revision of the hydraulic computations reduced the size to 16½ ft. As the moments vary nearly as the square of the arch radius, they were reduced by the ratio of $8.75^2/9.75$ or very nearly 80 per cent and applied to the new arch. The diagrams in Fig. 3 show the detailed loading for each case for the original 17½-ft. arch.

In this analysis the arch was divided into segments proportional to the moment of inertia, as given in Tourneaure and Maurer's partly graphical method for the elastic arch. The loads were concentrated at the center of each segment and moments taken about the same parts. The values for some of the critical moments and thrusts under each case are given in the accompanying table, reduced to apply to the 16½-ft. sewer.

The elevation of the sewer at the flow line will be about 10 ft. above low water in the Mississippi, while the crown of the arch will be about 10 ft. below high water. No rock is found east of Broadway, the soil being partly river silt and part artificial fill. At low water in the river it is probable that the excavation will not be difficult, while if part of the open cut work is done at a medium or high stage the soil is likely to be very wet and possibly flowing.

TRENCHING REQUIREMENTS

To meet the first case the specifications provide for lumber sheathing for the trench, to be left in place and paid for at a bid price. This planking is to be placed horizontally and braced across in three plank sets. When the cross bracing must be removed in order to set forms for the sewer the side planking will be supported by steel I-beams placed vertically against the plank and braced across above the forms. These beams must be concreted in as the sewer is poured and are, within certain limits, to be estimated and paid for.

For conditions where the trench cannot be supported with this type of bracing, steel sheet piling may be ordered driven. The top of the piling must not be above a point about 2 ft. over the arch, but if required the piling may have a penetration of 15 ft. below subgrade in order to cut off the flow of wet silt. In the latter case a raft of class B concrete is to be placed as a subfoundation. When the sewer is constructed between steel piling outside forms for concrete are required to be set, blocked out from the piling, and the intervening space filled with sand. Prices are taken on the sheet piling, on the concrete for the subbase and on the outside forms with sand filler.

Excavation prices are taken on class A or solid rock, and on class C, which is ordinary clay, loam, silt, sand, etc., without regard to moisture or water conditions. Where loose rock, cemented macadam of roadways and similar material is encountered it is paid for at twice the class C price.

It is expected that the concrete sewer will be constructed in three stages. The invert, side walls and arch, and the reinforcing has been detailed with that end in view. This sewer, except the possible subbase, will be entirely of class A concrete, as described in the tunnel specifications already quoted.

OUTLET

The outlet section of the sewer will be protected by reinforced concrete sheet piling, probably driven in advance of the sewer construction. This sheeting will extend across the face of the sewer and for 40 ft. back along each side. The piling will extend 20 ft. below the invert line and the tops are to be sealed to the concrete of the sewer. For a distance of about 40 ft. in front of the outlet additional excavation will be made to a depth of 4 ft. below the flow line. This space will be filled with stone, which will then be covered with class B concrete, forming an apron to receive the discharge of the sewer. Additional rock fill will be made on each side of the sewer along the river bank.

An existing 4 x 5-ft. brick sewer parallels the new work in Rutger Street. This sewer is overcharged and in bad condition, and after the completion of the concrete sewer will be practically abandoned. During construction the sewage flow of the existing sewer will be diverted at Sixth Street to another system on the south, but the sewer must be maintained to carry storm water. Its laterals from the south must be flumed over the work temporarily and then re-connected to the concrete sewer. This work, the reconstruction of street inlets and the maintenance and replacement of water pipe and services are all estimated and prices taken on the materials and units involved.

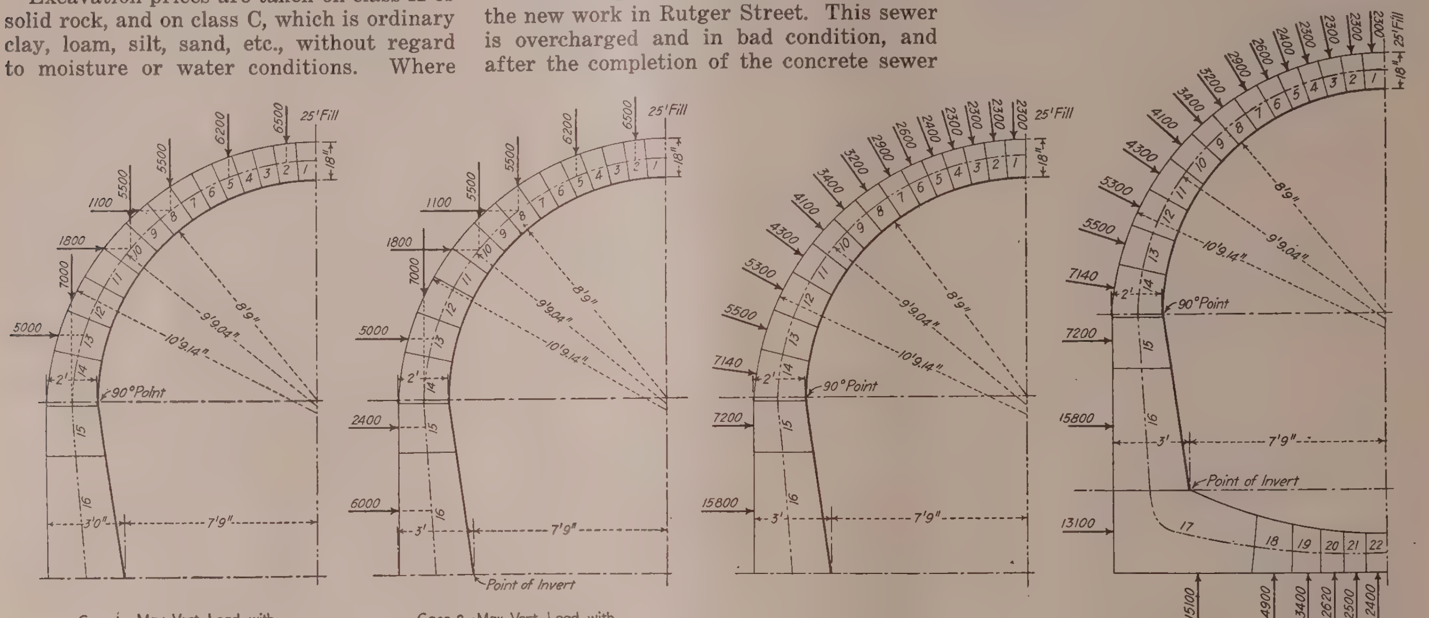
Rock is encountered on the east side of Broadway, Sta. 20, at the sub-grade, and rises rapidly until at Sta. 22 it is 4 ft. over the crown of the arch. This station has been fixed as the point of division between open cut and tunnel work, but the contractor is permitted to extend the tunnel eastward from Sta. 22. He probably will find the extra tunnel economical for at least 150 ft., as payment for this extra tunnel will be made as if the work were done in open cut.

TUNNEL AND SHAFTS

About 800 ft. west of the portal a fissure is encountered where the crown of the arch will be out of rock for about 125 ft. and the whole sewer may be in soft ground for a few feet. Unless some seam is encountered which was not found in prospecting the remainder of the tunnel work in both sections will be through good limestone, except for a section about 250 ft. long, near Sta. 190, where the rock drops to about the level of the arch crown and is overlaid with boulders and fine sand. To provide for any contingency that may arise at this point, two lump sum bids are taken. The first is to cover the whole cost of providing air pressure for the section and to cover all extra cost incident to work under compressed air. The second is to cover the cost of furnishing, erecting and operating a shield at this point. Additional borings taken since the completion of the plans indicate that it is quite possible that neither of these special provisions will be used.

It was somewhat cheaper to have the construction shafts permanently lined and finally covered than to pay prices for shaft excavation which would include the cost of a temporary lining and the back-filling, and there is also a decided advantage in having the shafts available for entrance. The plans provide for a detachable cover of protected steel beams and reinforced slabs. The top of the cover will be about 5 ft. below the street and will be buried except for a 2 x 4-ft. manhole extension. Two of these construction shafts are provided in the first section, tentatively located at Sta. 29 + 25 and 69 + 05, but the location may be changed somewhat on agreement between the contractor and the department.

In the scheme for this work it was expected that the headings from the east shaft at Eighth Street would be worked



Case 1 – Max. Vert. Load, with Horiz. Load to 90-Degree Point

Case 2 – Max. Vert. Load, with Horiz. Load to Point of Invert

Case 3 – Hydrostatic Pressure

Case 4 – Sewer in Soft Ground – Hydrostatic Pressure

FIG. 3—DIAGRAMS OF LOADINGS FOR ARCH IN OPEN CUT, USED IN DETERMINING BENDING MOMENTS AND THRUSTS

BENDING MOMENTS AND THRUSTS IN 16½-FOOT SEWER

(Moments in thousands of inch-pounds; tangential thrust in thousands of pounds.)

Point	Case 1		Case 2		Case 3		Case 4		Case 5		Case 6	
	Moment	Thrust	Moment	Thrust	Moment	Thrust	Moment	Thrust	Moment	Thrust	Moment	Thrust
Crown	131	13	123	13	—59	28	—110	27	+60	14	—25	24
1	+131	13	+123	13	—59	28	—110	26	+60	14	—25	24
2	+131	13	+123	13	—58	28	—110	26	60	15	—25	24
3	+93	14	+88	14	—53	28	—92	26	31	15	—15	24
4	+82	14	+77	14	—47	28	—82	26	27	15	—13	24
5	+73	15	+70	15	—27	28	—58	26	+27	10	+0	24
6	+17	17	+15	17	—12	28	—48	26	—16	17	+0	24
7	—12	17	—13	17	—2	28	—21	26	—32	18	+12	24
8	—30	18	—30	18	+10	28	0	26	—32	18	+12	24
9	—78	19	—75	20	+36	28	+36	25	—56	20	+24	24
10	—110	21	—105	22	+54	28	+67	25	—60	20	+26	24
11	—161	24	—155	24	+76	28	+105	25	—78	22	+29	24
12	—184	24	—173	24	+82	28	+130	25	—60	22	+13	24
13	—147	24	—134	24	+102	28	+170	25	+20	22	+9	24
14	—116	24	—119	27	+76	28	+170	24	+108	22	—51	24
15	+30	24	+32	27	+50	28	+171	25	...	..	...	..
90° Pt.	...	..	...	..	...	..	...	..	+173	22	—88	24
16	+284	27	+280	27	—220	28	—34	25	...	..	...	..
Pt. of Inv.	+495	27	+325	27	—720	28	—510	26	...	..	...	..
17	...	..	...	..	...	..	—430	24	...	..	...	..
18	...	..	...	..	...	..	—120	30	...	..	...	..
19	...	..	...	..	...	..	—14	29	...	..	...	..
20	...	..	...	..	...	..	+23	29	...	..	...	..
21	...	..	...	..	...	..	+115	29	...	..	...	..
22	...	..	...	..	...	..	+118	29	...	..	...	..
Center of invert.	...	..	...	..	...	..	+118	29	...	..	...	..

about 900 ft. to the east and about 1500 ft. to the west, the eastern heading being the most difficult portion of the tunnel. All mucking from this shaft would be by hand. From the shaft at Sta. 69 + 05 the headings would be about 2500 ft. in each direction and mechanical mucking was planned.

If the contractor should adopt some other scheme for this work he will be permitted to change the shaft location as stated or he may put down other shafts, but no additional shafts will be paid for.

The end of the first section is at Sta. 95. The length of the second section is 10,500 ft. and it will all be in tunnel; there are, however, one large lateral and one smaller one in open cut.

On the second section there are four large shafts and three smaller ones. Two of the large shafts are construction shafts only, and are located at Sta. 112 + 20 and 149 + 00. At Sta. 188, there is a special shaft which will be used for construction and then partially rebuilt as an intake or drop shaft. The terminal shaft at Sta. 200 is the intake for the greatest amount of flow; with some modification it also may be used for construction, but there seems little probability that this will be of advantage.

INTAKES AND DROPS

The unusual feature of the second section is the design of the four intakes or drops. The essential features are the same in each case and are, first, a diversion chamber on the existing sewers which will permit the ordinary sewage and the run-off from a very light shower to pass on into the old Mill Creek sewer, but which will force any flow in excess of this amount over a weir into the new system; second, a section of lateral sewer from the chamber to the drop shaft, where required; third, the drop shaft, and fourth, an easy connection at the bottom of the shaft with the main tunnel. Every precaution has been taken to prevent the discharge of any concentrated sewage into the tunnel except east of Sixth Street, where there was no alternative. This is an important feature, as it is a possibility that the tunnel may be filled with backwater from the Mississippi for over thirty days at a time, and it is also possible that no appreciable rainfall would occur during this period. The admission of much sewage then would result in the gradual expulsion of the river water and the setting up of septic action in the tunnel, with unpleasant and possibly expensive consequences. Another advantage in the retention of the whole sewage flow in the old trunk sewer will be the continuance of high sewage velocities in that sewer and absence of deposit and sewer gas, now a conspicuous feature of that main.

With the sewage eliminated, the only possible deposit of any great amount will be river silt. During a rise of the river from an elevation of —25.0 to —8.5 or above, a total volume of 4,500,000 cu. ft. of raw river water will pass into the sewer unless a rain occurs during the rise. This might result in the deposit of as much as 700 cu. yd. of mud in the sewer. The velocities upstream will be so small that nearly all of this must be deposited near the mouth and there can be no doubt that the enormous power which would be developed by a partial blocking of the mouth would clean the sewer in the first minutes of the rain.

Self-Supporting Concrete Arch Reinforcement of Structural Shapes

Four Large Bridges at Fort Worth, Texas, Have Been Built by a Method Which Eliminates Use of Falsework to Carry Forms

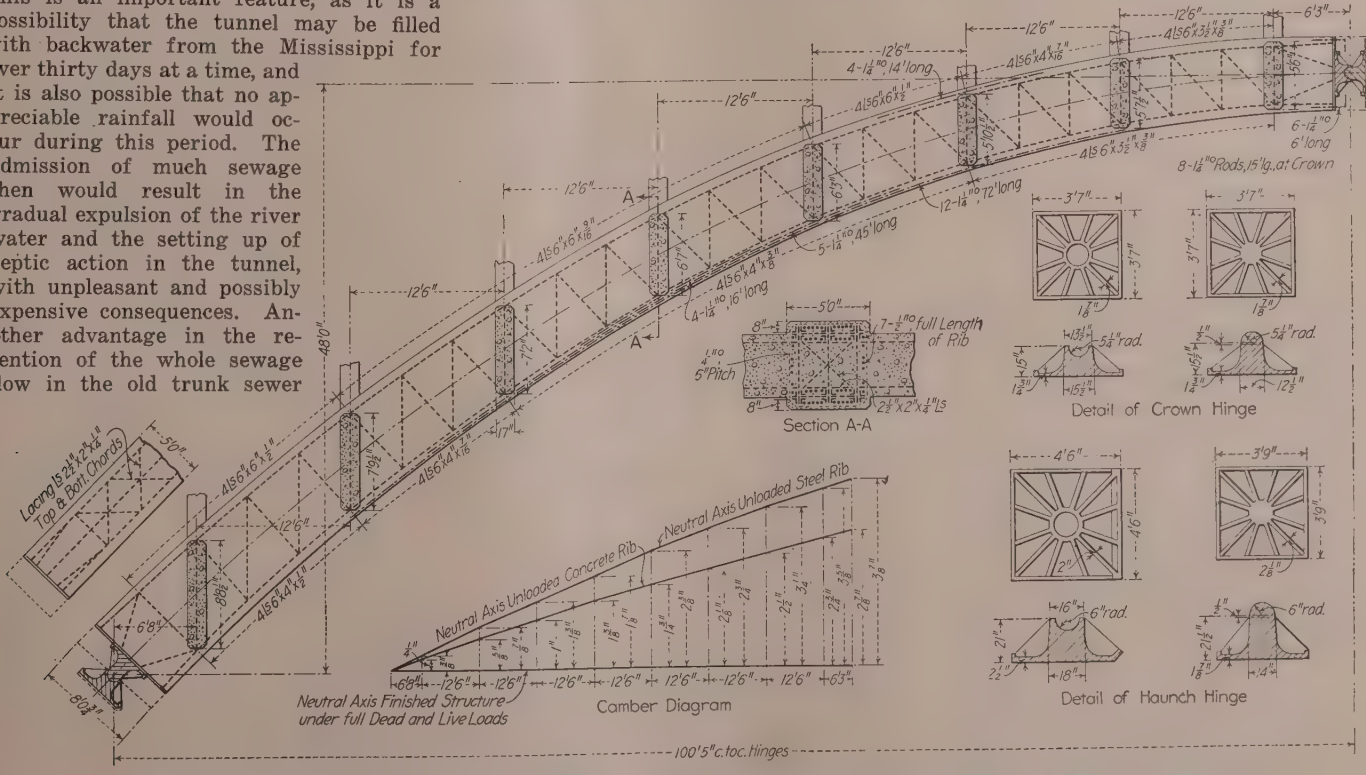
REINFORCED-CONCRETE arch bridges, in which the reinforcement is composed of structural shapes and designed to support the weights of forms and plastic concrete, are discussed in a paper entitled "The Design and Construction of Four Reinforced-Concrete Viaducts at Fort Worth, Texas," to be presented by S. W. Bowen on Oct. 21 before the American Society of Civil Engineers. This paper is printed on page 1761 of the August "Proceedings" of the society and the following is a short abstract of that article.

In the clear the spans of the arches ranged from 125 to 200 ft. in length. Three-hinged, ribbed arches were used having hemispherical ball and socket, cast-steel hinges. No falsework was used except comparatively light timbering necessary for the erection of the structural steel reinforcement of two of the spans. For high structures and for those over streams subject to sudden and great variation of water level this method is considered cheaper and safer than falsework supported from the bed of the stream.

ARCH RIB REINFORCEMENT

Reinforcement of arch ribs and braces consists of medium-steel structural shapes, supplemented by reinforcing bars. Structural shapes are also used for the main supports of the stairways. All other reinforcement consists of square twisted bars, of high elastic limit. As shown on the plans, the rib reinforcement consists of curved lattice girders, to the ends of which are bolted cast-steel hinges. The chords of these girders are made up of four angles arranged in the shape of a cross. All web members are made up of two angles. Three of these steel girders are used in each inner and two in each outer rib of each span. The individual steel girders are laced together in the plane of the top and bottom chords, and are also connected by transverse frames, in vertical planes, under each post. The transverse braces connecting the four ribs are reinforced by lattice girders attached to the rib reinforcement. No reaming or painting was called for. The hinge castings are bolted to the steel ribs, and all other connections are riveted. At each upper panel point of the steel ribs clip angles were provided, to which were secured the transverse timber beams, supporting the rib forms.

A system of lateral rods, for use during erection, was provided in the plane of each chord of the ribs. These rods were used to line up the steelwork, and to hold it in line while the ribs were concreted. These rods were not removed until after the completion of the work. The transverse braces are also reinforced in each face with continuous bars, the function of which is to



DETAILS OF SELF-SUPPORTING REINFORCEMENT FOR AN ARCH RIB OF 200-FOOT SPAN IN FORT WORTH, TEXAS resist bending in the braces due to transverse forces.

In addition to the steel reinforcement required to resist the calculated stresses in the members, a certain quantity of steel is used to prevent the formation of shrinkage, settlement and temperature cracks. This steel is used in the exterior faces of thin walls in a longitudinal direction in the slabs, and to reinforce the corners where two walls join. All braces, ribs and posts are wrapped with heavy wire closely spaced, to which the longitudinal steel is secured.

STRESSES

The structural steel arch rib reinforcement takes stress in two independent steps: First, as the ribs are filled with concrete the members take certain initial stresses, which, as the concrete sets, remain in the steel. This initial stress in the steel was not allowed to exceed a maximum of 12,500 lb. per square inch in compression, as given in the list of unit stresses. Second, after the ribs are finished and the construction of the posts and deck is under way, and later, when the structure is carrying live load, stresses are set up in the ribs, and carried jointly by the steel and concrete in the usual manner. The assumed ratio of the moduli of elasticity of steel and concrete was taken as fifteen. The maximum possible compressive stress, therefore, in the structural steel reinforcement of the ribs would be 12,500 lb. plus fifteen times 500 lb., or 20,000 lb. per square inch. This is based on the assumption that the ribs and braces are completely filled with concrete in such a short time that it does not begin to set before all the load is in place, and also, that the stress in the concrete at the center of gravity of the steel chord is 500 lb. per square inch. As a matter of fact, the ribs were concreted in sections, and the braces were not concreted until the concrete in the ribs had set for several days. Consequently, the initial compression in the structural reinforcement was less than that mentioned above. The center of gravity of the steel chords is some distance in from the face of the concrete, so that the concrete stress at this point, and, therefore, the stress in the steel, is lower than that assumed. The actual maximum compression in the structural reinforcement is about 16,000 lb. per square inch.

LINES OF PRESSURE

Lines of pressure for the ribs were worked out graphically for the various positions of the live load, combined with dead load, and for the various stages in the construction of the deck. In order to allow for the weight of the ribs themselves, their dimensions were first assumed, and later were revised where necessary. The neutral axes of the ribs were drawn midway between the extreme pressure lines. This made the neutral axis of the rib a constructive curve, approximating a parabola with its apex at the crown of the arch. The axis as drawn followed closely the pressure line for full dead and live load. The inner and outer ribs were made of the same vertical dimensions, but of different thickness.

The next step was to find the stresses in the reinforced-concrete rib for the various stages in the construction of the deck, and for the dead and live load, under working conditions in the finished structure. The quantity of steel required at each point to keep the extreme fiber stress in the concrete down to 500 lb. per square inch, for the worst condition, was then computed. The required area of steel in either face of the rib at any point was not allowed to exceed 2.5 per cent of the total cross-sectional area of the rib. Where, on first trial, the required quantity of steel exceeded the above maximum, a re-design was made, using a rib of a larger cross-section.

Transverse forces of wind and water pressure, were assumed to be resisted wholly by the ribs and braces acting as a series of portals, in the same manner as the columns and girders of an office building act to resist wind pressure. The deck was not given credit for any resisting power, because of the presence of the expansion joints over the haunch and crown.

Arthur's Pass Tunnel in New Zealand

Narrow-Gage Single-Track Bore 5.3 Miles Long on Railway Across South Island—Concrete Lining with Crown of Concrete Blocks

By H. VICKERMAN
Public Works Department, Wellington, New Zealand

ARTHUR'S PASS tunnel is, with the exception of a small length of approach line on the eastern side, the last remaining work on the section of the State-owned New Zealand Midland Railway which is being built to connect the town of Christchurch, on the east coast of the South Island, with Greymouth and its surrounding coal fields and forests on the west coast. The island lies approximately northeast and southwest, is about 480 mi. long and averages some 100 mi. wide. The main divide, through which the tunnel is being made, is a range of mountains running parallel to the long axis.

Topographical conditions are such that the base of the range on the east side is about 1000 ft. higher than that on the west. This difference of elevation presented the Arthur's Pass problem, which was made more difficult by the gorges of the west, whose steep and, in parts, loose shingle-covered sides are almost impracticable for railway building.

Consideration was given to an overland route without tunnels, and also to various tunnels of different lengths and grades. On the recommendation of a commission of New Zealand Government engineers, with the confirmatory advice of Virgil G. Bogue, consulting engineer, of New York City, a line was adopted giving a straight tunnel 5.3 mi. long, all on a rising grade of 3 per cent. The Otira or western portal is at El. 1585 above sea level and that at the Bealey or eastern end, El. 2435. The cover is in general about 850 ft., with a maximum of 1130 ft. 2¼ mi. in. Where the Otira River crosses the line the cover is 800 ft.

TUNNEL DESIGN

The country pierced is rock throughout. Owing to the strata being on end, surface water has found its way down readily and in some places work has had to be carried on under very wet conditions. The design of tunnel adopted is shown. It provides for a single track of 3½-ft. gage, the clear width of tunnel being 15 ft. and the height from rail level to the crown of arch soffit 15 ft. 6 in. Two sections are provided, one, with an arched concrete invert, for heavy ground, and the other with no invert, for lighter ground. So far the latter is the only one that has been used. The tunnel is to be lined throughout. The lining is of mass concrete to about half way up the arch, the remaining portion being lined with wedge-shaped concrete blocks. Generally one ring of blocks is used, but in very bad places there are two. Drainage is provided by a concrete channel with a removable slab top at the side. Refuges are provided for trackmen every 330 ft., all on one side. There is no special provision for permanent ventilation; owing to the steep grade, all one way, and the intended use of electric traction, it is not thought that this will be necessary.

Where the lining is 12 in. thick the quantity of excavation per foot run is 10½ cu. yd. The quantity of lining per foot run when twenty-five blocks are used, as is specified, is 1.2 cu. yd. of mass concrete and 0.77 cu. yd. of blocks, these quantities being neat.

CONTRACT FOR CONSTRUCTION

After inviting tenders in England, the United States, Australia and New Zealand for the construction of the tunnel and about 1½ mi. of approaches on each side, making 8 mi. of railway in all, a contract was let to a New Zealand firm of contractors. The date of letting was Aug. 1, 1907, and the date for completion Aug. 1, 1912, the price being equivalent to about $2,900,000, including $150,000 for the work on the approaches. The price per linear foot of tunnel was therefore about $98. The unit costs per cubic yard, reduced to dollars were as follows: Excavation, $5.10; concrete in mass for wall lining and side drains, $13.85 at Otira and $16.50 at Bealey; concrete in manholes, $16.50; drain covers, $17; arch blocks in position, $15.05 at Otira and $18 at Bealey. These prices cover any packing required. The extra cost of Bealey is on account of extra cartage over very steep roads.

In May, 1912, the contractors found themselves in financial difficulties and after various negotiations the contract was terminated at the end of December, 1912. On that date the contractors had completed almost 1.9 mi. of tunnel and had a further ½ mi. in hand. Since the termination of the contract the Public Works Department of New Zealand has carried on the work. At the beginning of March, 1914, the length completed was 2.45 mi., with a further 2400 ft. in hand.

The contractors began work at both ends but figured to do the bulk from the Otira side to avoid the haulage of spoil up grade and the necessity for pumping to keep the face clear of water. As a result the arrangements and plant were more complete on the Otira side. Separate hydroelectric power stations were installed at Bealey and Otira, each of 300 hp., the power being obtained from small creeks with steep fall. These in ordinary weather afforded a satisfactory supply, but each year during the frosty season there was a shortage of water and a consequent lack of power and serious disorganization of work. In view of this experience the Public Works Department is now installing an auxiliary steam generating plant of 290 hp., delivering, as do the water plants, direct current at 500 volts.

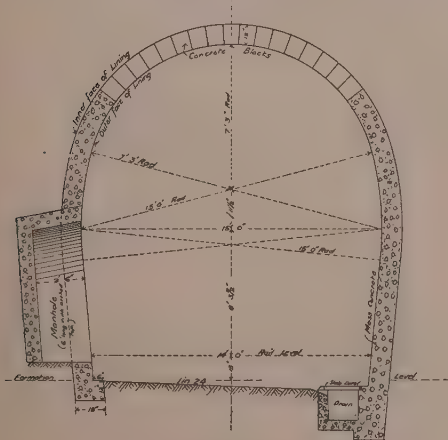
EXCAVATION

The "bottom heading" method of excavation has been followed throughout. In this, the bottom heading, 8 ft. high by 10 ft. wide for single track and 8 x 12 ft. where sidings are required, is taken out first and is kept well in advance of all other operations, generally from 300 to 1100 ft. This is followed by the excavation of a top heading in the center of the tunnel 8 to 11 ft. wide, with a height of about 11 ft. from the roof of the tunnel to the roof of the bottom heading. Some 60 ft. behind the top heading the widening out of the arch on each side of it to full width is carried on by a separate party. About 100 ft. behind this, again, another party is engaged in breaking down the side walls on each side of the bottom heading and widening out to the full width and the correct contour, and 50 ft. further back men are employed excavating the footings for side walls and the drain.

The drills used are chiefly of the Ingersoll-Sargent make, with star bits. Those in the bottom and also in the top headings are 3¼-in. rigged on a 4½-in. bar, from two to three being used in each place. One or two 3¼-in. bar-rigged drills are used for breaking down the arch. Tripod-rigged 2½-in. drills and hand jackhammers are used for breaking down the walls, trimming and excavating the drain and footings. No drill carriage is used in the heading face. The air is supplied from two two-stage Ingersoll-Rand air compressors.

The usual scheme of cut holes is used in the heading faces. Holes are drilled from 4 to 6 ft. deep according to the hardness of the rock. In the bottom heading from ten to sixteen holes are bored and in the top from nine to twelve, the larger number being required where the rock is hard. In soft rock Nobel's gelignite is used, but in hard, up to 50 per cent of blasting gelatine is used with it. The quantity of explosive used in excavating 1 cu. yd. averages as follows: Heading, 4.4 lb.; enlarging arch, 1.4 lb.; widening out side walls, 0.34 lb.; footings, 2.5. Five fuses are used.

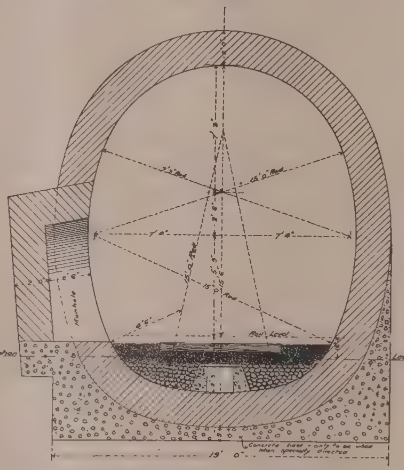
While the tunnel was in the contractors' hands, ventilation was provided by forcing, by means of a 55-hp motor-driven Roots blower, fresh air into the tunnel. Since the contract has been taken over the process has been reversed and the blower arranged to act by suction, a change attended with very beneficial results. In addition a 30-hp booster blower has been fixed in the pipe line 1½ mi. from the portal to avoid the necessity for larger pipes and more power outside as the air supply was falling low. Others will be placed at ¾-mi. intervals as the work proceeds.



TYPICAL CROSS-SECTION OF TUNNEL

TIMBERING

As a rule the bottom and top headings have not required timbering, except to prevent flakes falling. Where more than this has been required the side-pole and cross-timber system has been adopted. Following the completion of the bottom heading and before beginning the arch excavation a timber stage about 7 ft. high is built in the heading to serve as a floor for catching the spoil produced in the top heading and arch widening. This is made of sets, on 4-ft. centers, of round timber legs and caps, well wedged against the side walls and with a split timber deck above. It is provided with suitable trap doors to enable wagons standing below to be readily filled with excavated material from above. This stage is taken down and utilized again ahead as the enlargement of the arch is completed.

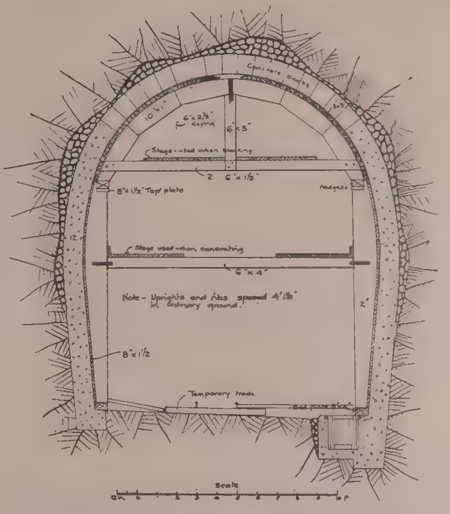


SPECIAL CROSS-SECTION FOR BAD GROUND

For timbering the fully enlarged arch, where the ground is heavy and requires support, the English crown-bar system is employed. As a rule the sets are 16 ft. 6 in. in length. The timbers used are shown in one of the illustrations. Under the circumstances the system is convenient. It gives a sufficient clearance for traffic and sets can be easily rigged as the arch is enlarged from the top heading, by tomming successive bars up temporarily from the rock and repropping off the main sill when excavation admits of this being placed. There is seldom much difficulty in removing all timbers where lining is being carried out.

REMOVAL OF TUNNEL SPOIL

For the removal of the spoil a single-track railway of 2½-ft. gage, electrically operated, has been laid on the western side from the face to the railway approach bank, some 2¼ mi. distant, in the construction of which the tunnel spoil is being used. Two-yard side-dump cars are employed, each fitted with a powerful screw brake, a necessary adjunct on account of the steep grade. The two locomotives are of the 20,000-lb. 100-hp Jeffrey electric mining type. To enable them to run beyond the end of the completed tunnel, where the trolley wire ceases, they are each fitted with a drum carrying some 1300 ft. of insulated cable which can be hooked to the end of the trolley wire and run out.


Concrete blocks
10"x1"
6"x2½" for Keying
6"x3"
Stage - used when blocking
2 6"x1½"
8"x1½" Top plate
12
Stage used when concreting
6"x4"
Note - Uprights and ribs spaced 4'1½" in ordinary ground.
2"
8"x1½
Temporary track
Scale

DETAILS OF FORM WORK AND STAGING

Some twenty-four to twenty-eight empty cars are supplied at the working faces each four hours. These are pushed in by the locomotive as far as the staging beneath the top heading. At this point six are detached and hauled ahead to the bottom-heading siding by an air winch. As required for the removal of the débris at the heading face, single trucks are winched forward from that point, and when filled are allowed to gravitate down again past the siding, dragging up the next empty.

The other eighteen trucks, which were left under the staging, are lowered by gravity to the various points where enlargement is going on. When filled they are allowed, as are also the loads from the bottom heading, to gravitate to a siding placed some distance down the tunnel, remaining there until the next train of empties passes up. On the return of the locomotive after pushing up more empties, they are hauled to the fill and dumped off a trestle some 30 ft. high.

No mechanical shoveling machine is in use. At the bottom heading from two to five men, according to the nature of the ground, are employed filling the spoil into cars. At the top heading and places where enlargement of the arch is being done the spoil is dropped through chutes into the cars placed below. Where the side walls are being broken down and where footings and drains are being excavated, men hand-shovel all spoil into cars alongside.

CONCRETE LINING

The tunnel will be concrete-lined throughout. The lining is in general 12 in. thick, but in parts, on account of the heavy ground, this has been increased to 18 or 24 in. It is placed in mass except for a portion of the crown, which is lined with blocks as shown in one of the illustrations. In the original contract it was provided that there should be twenty-five blocks covering a strip about 19 ft. wide, but at the request of the contractors this was reduced. The width adopted was then made optional with the contractors, except that a minimum of seven blocks must be used, covering a 5½-ft. strip. At the contract rates it is found that this is a most economical number to use, and the work is being carried out accordingly.

The cement is of New Zealand manufacture and is delivered at the works in bags of 125 lb. capacity. The sand, which is coarse, is obtained partly from the Rolleston River, which runs past the western portal, and partly from a point some 6 mi. lower. The stone is obtained partly from tunnel spoil, but chiefly from shingle banks in the adjacent river bed. The concrete for both walls and blocks is a 1:2:5 mix.

ARCH BLOCK MAKING

The arch blocks are 12 in. deep, 18 in. long and 9 in. wide on the soffit, and weigh 168 lb.

Block-molding operations are carried on outside the tunnel. The concrete is mixed in a Ransome mixer and filled by hand into knockdown wooden molds. These molds take three blocks each, and four molds are filled at each operation. During filling these four molds are supported crosswise on a trolley which stands on a steel vibrating table near the mixer. This table is 12 x 7 ft., is driven by a 6-hp motor and makes 300 complete vibrations per minute, the vibration consisting of a seesaw motion of ¾ in. at the ends and simultaneously a ⅜-in. sideways oscillation. The mixture is made moderately wet, and after shaking no further tamping is required. The trolley, which is so constructed that the deck can be raised or lowered 1½ in. by a lever, and which is in a raised position while being loaded, is then run off to the curing shed. This has four parallel longitudinal tracks running between skidways placed 3 ft. apart and 21 in. high, allowing the truck deck to clear when in the raised position. On arising at the desired point the deck is lowered and the molds are deposited. The trolley is then run under four empty molds, which are lifted by raising the deck and then taken to the mixer, when the process is repeated.

After two or three days the sides, ends and partitions of the molds are stripped and the blocks left standing on the mold bottom for a further five days. By reversing the process of depositing they are then removed on the same truck to the stacks in the storage yard. After standing here a further minimum of six weeks, they are allowed to be used in the tunnel.

METHOD OF PLACING LINING

For the mass concrete a Ransome mixer outside the tunnel delivers into low trucks with 11 x 4-ft. decks and 15-in. sides, with the ends removable for shoveling. From 4 to 6 cu. yd. are pushed into the tunnel at one time, between the four hourly trips for excavated material.

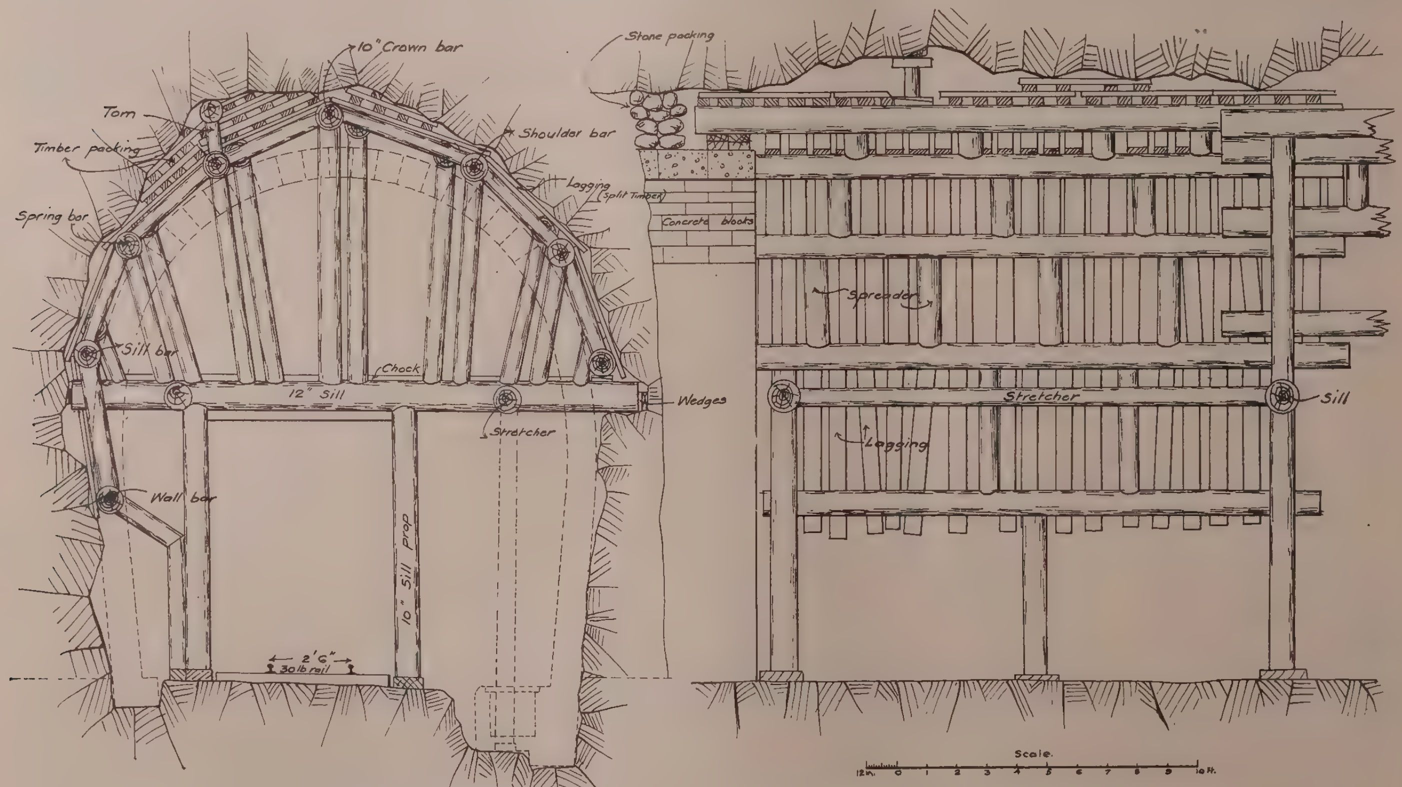
The footing and drain concrete is placed first, in lengths of from 200 to 300 ft. The wooden sills are later placed along this and the verticals for the side-wall timbering are then erected. Any convenient length of this is undertaken at one time, the height being 10 ft. The concrete is shoveled directly from the car into the forms until the wall is about 6 ft. high. Above this it is shoveled from the truck to a stage erected on the transverse stretches between the verticals and thence into the wall. After the concrete is placed to this height the arch ribs are set and the mass concrete is completed to the point where the blocking begins. A stage is then erected on the arch-rib ties and the blocks and mortar are hoisted to this from below. The blocks are then carefully placed by hand, using a 3:1 mortar and a single ring of blocks—except in very bad ground, where another and independent ring is built outside.

The rate of progress is necessarily regulated by the progress made with the excavation, the concreting being kept as close as possible. Seven men from a gang on mass-concrete work do from 50 to 60 ft. per week. Eight men on blocking do from 60 to 100 ft. per week.

The advance of the bottom heading was recognized as the governing factor in the progress of the tunnel. Owing, however, to labor union troubles and the continual scarcity of men, it has proved very difficult and at times impossible to keep the widening out progressing at the same rate as the heading.

The shortage of men, and to some extent the narrow width of the tunnel, prevented any speed record being made. Apart from the direct effect of preventing progress, the want of men exerted other evil and indirect influences: The indispensability of the men led to their doing a poor day's work; a proper organization of men was impossible, owing to the shifts frequently being short and the men inexperienced; the distance between the heading and the breaking down could not be kept regular, and the cost of an elastic outside organization suitable for rapid progress inside added such expense to the work that it became unprofitable. It was this cause chiefly which led to the contractor's undoing. It should be mentioned that occasionally shortage of power and hard and wet ground led to delays.

Consideration of these facts indicates that under local conditions it would have been impossible to carry out the contract in the five years specified; it also shows that the local conditions were not realized when the first organization was arranged and that no successful nor very radical effort was made later to conform to them. Any proposal to introduce foreign labor would almost certainly have been negatived by the Government. Any change made must, therefore, have been in the following direction: Reorganizing the outside and reducing expenses there to a minimum; introducing a method different from the "bottom heading" method, which could only be justified on the ground of having enough men to carry on the widening out in several places; introducing mechanical means of shoveling; using more powerful and faster drills, with drill carriages; having more light; using a more quickly fitted up system



DETAILS OF ENGLISH "CROWN-BAR" SYSTEM OF TIMBERING, AS USED IN ARTHUR'S PASS TUNNEL of timbering, and using a mechanical means of depositing concrete. These changes would have involved having more power, but need not have increased outside expenses, whereas they would have resulted in a greater output per man from the inside, and so, the writer believes, would have led to a profit where a loss was sustained.

WAGES AND BONUSES

The men employed are chiefly Colonials and English. They are a fair average, but lack the natural genius for tunneling possessed by some European nations and the enthusiasm for organization and record making which marks American workers. The rates paid are as follows per 8-hr. shift, or in wet places, per 6-hr. shift. Shift bosses, in charge of four to ten men, \$2.92; machine men, \$2.67; laborers, \$2.43. In addition a bonus is paid which amounts to about 10 cents per day, depending on the number of cubic yards excavated. In the bottom heading further inducement by way of additional bonus is offered. This is payable on all feet driven over 100 ft. for twelve days of three shifts, and works out per man per day as follows: For 125 ft., 16 cents; for 150 ft., 43 cents; for 175 ft., 82 cents; for 200 ft., \$1.34.

The average total number of men employed inside and outside the tunnel is 160 at the Otira end and sixty at the Bealey end. It is estimated that 100 more could be employed without increasing the plant and outside organization.

The progress of the work is being watched with considerable interest throughout New Zealand, as it is the largest undertaking of its kind so far undertaken, although owing to the mountainous nature of parts of the country a large number of tunnels of smaller length are in existence on various sections of the railway system. If progress continues the same as in the past the completion may be looked for early in the year 1919. The advent of a train connection between the east and west coast will be welcomed in commercial circles and will mean much in relieving the isolation to which the west coast has hitherto been condemned.

Anchoring Base Plates for Columns

Prevailing Method of Figuring Stresses Is Shown to Be Incorrect, Giving Values from 12 to 50 Per Cent Too Small

DESIGNING base plates for columns necessitates dimensioning them so that, first, the maximum unit load on the foundation will not exceed the permissible, and, second, the foundation bolts will not be over stressed. If only vertical and central loads have to be taken care of the problem is simple, but if, in addition, horizontal forces due to wind pressure and the quick stopping of rapidly moving crane trolleys, and vertical and eccentric reactions from brackets supporting crane girders and other loads have to be taken care of, moments have to be resisted. In "Zentralblatt der Bauverwaltung" of Aug. 26, Diplom-Ingenieur Wendt, of Berlin, analyzes this problem and proves that formulæ based on the common equation $\sigma = (P/A) \pm (M/S)$ are seriously incorrect.

In Fig. 1 R is a central and vertical load; M, the total overturning moment around the point B; h and b, length and width of base plate, and a, distance from edges to center of anchor bolts. The moment M can be replaced by an eccentric and vertical load equal to R placed at a distance $p = M/R$ from the axis of the column.

The shear, that is, the sum of all horizontal loads, is taken care of by friction on the masonry of the foundation. Assuming that the coefficient of elasticity E_d of the masonry is a constant, that the base plate of the column, even after deformation, is a plane and that the stresses are in a direct proportion to the deformation, $D = \sigma bx/2$ (See Fig. 2). In order to determine the three variables, σ, the maximum unit stress; x, the distance from edge to neutral axis, and Z, the pull on the anchor bolts, three equations are needed. Two of them are given in the expressions $\Sigma V = 0$ and $\Sigma M = 0$, while the third can be derived from the deformation diagram in Fig. 2. Thus

$$R + Z - D = 0 \qquad (1)$$

$$R\,[(x/3) \pm e] - Z\,(h' - x/3) = 0 \qquad (2)$$

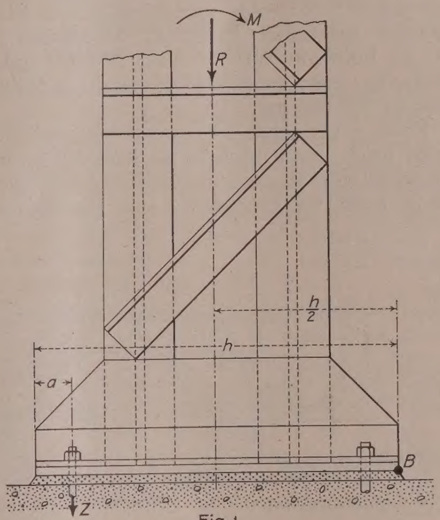


Fig. 1

(the minus sign on e to be used when R falls inside the base plate) and

$$\Delta l_z/\Delta l_d = (h' - x)/x \qquad (3)$$

Let it also be assumed that both materials follow Hooke's law, thus $\Delta l_z = Zl/Ef$ and $\Delta l_d = \sigma l/E_d$, which gives

$$(Zl/Ef) \div (\sigma l/E_d) = (h' - x)/x$$

from which the stress

$$\sigma = Z\,[E_d x/Ef\,(h' - x)]$$

is obtained.

For E/E_d is used the value for steel and concrete, $n = 15$, which gives

$$\sigma = (Z/nf)\,[x/(h' - x)] \qquad (4)$$

The area at the base of threads of the bolts is f. Introducing in equation (1) the value of σ from equation (4) (it must be remembered that $D = \sigma bx/2$), solving R and substituting the value of R obtained in equation (2),

$$\left[\left(h' - \frac{x}{3}\right) \Big/ \left(\frac{x}{3} \pm e\right)\right] + 1 = \frac{b}{2nf} \cdot \frac{x^2}{(h' - x)}$$

From this equation x can be solved

$$x^3 \pm 3ex^2 + \frac{6nf\,(h' \pm e)}{b}\,x = \frac{6nf\,(h' \pm e)}{b}\,h'$$

In practical calculations it will be found more convenient to use the form

$$w^3 \pm ew^2 + 3Cw = Ch'$$

where $w = x/3$ and

$$C = 10f\,(h' \pm e)/3b$$

As soon as w is solved it has to be introduced in equation (2), which rewritten reads

$$Z = R[(w \pm e)/(h' - w)]$$

and in equation (1), which can be written

$$\sigma = (Z + R)/1.5wb$$

For practical purposes the value of w can be quickly found either from tables or by means of a slide rule.

EXAMPLE

A given base plate has the following dimensions: $h = 80$ in., $b = 40$ in. and $a = 8$ in.; M is 6,000,000 in.-lb. and $R = 30{,}000$ lb., making $p = 200$ in.

In accordance with the formulæ commonly used

$$Z = R[p - (h/2)]/(h - a) = 66{,}700 \text{ lb.}$$

requiring a net area of foundation bolts of $f = 66{,}700/12{,}000 = 5.55$ sq. in. If two 3¼-in. bolts are used the unit stress will be $66{,}700/5.758 = 11{,}600$ lb. per square inch.

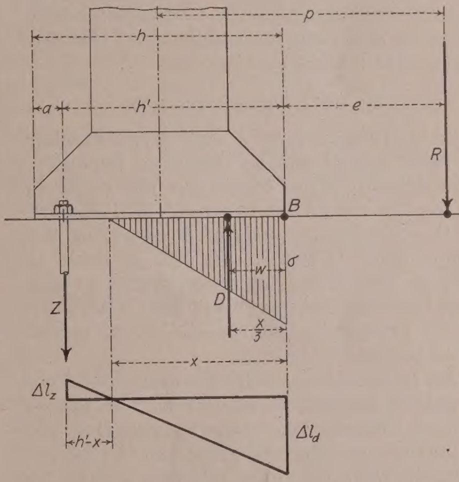


Fig. 2

To determine the maximum unit stress the formula $\sigma = (P/A) \pm (M/S)$ is generally used, which in this case would give

$$\sigma = (30{,}000/40 \times 80) + (6 \times 6{,}000{,}000/40 \times 80^2) = 150 \text{ lb. per square inch.}$$

In accordance with the formulæ of Mr. Wendt these stresses are incorrect and the following stresses will prevail:

$$h^1 = 80 - 8 = 72 \text{ in.}$$

$$e = 200 - 40 = 160 \text{ in.}$$

$$C = 10 \times 5.758\,(72 + 160)/3 \times 40 = 111.3$$

and

$$w^3 + 160w^2 + 3 \times 111.3w = 111.3 \times 72$$

It is close enough to use $w = 6$ in., which gives

$$Z = 30{,}000[(6 + 160)/(72 - 6)] = 75{,}500 \text{ lb.}$$

Consequently, $75{,}500/5.758 = 13.200$ lb. per square inch and $\sigma = (75{,}500 + 30{,}000)/1.5 \times 6 \times 40 = 294$ lb. per square inch.

It is apparent that the stresses obtained by the old method are seriously incorrect and that the figures in the new formula are more trustworthy.

DIAMOND DRILLING IN CHICAGO by two city outfits totaled 4964.4 ft. in 1913, according to report of the Board of Public Works, at a cost per foot of \$1.32 for labor, 13 cents for material and 29 cents for wear of diamonds and deterioration of outfits. Two drills, a Standard and a Longyear, did the work with minimum and maximum costs per foot of \$1 and \$2.08 respectively.

American Society of Municipal Improvements

Abstracts of Some of the Technical Papers Presented at the
Twenty-first Annual Convention, Held in Boston, October 6-9

Limitations of Water Filters

By GEORGE W. FULLER
Consulting Engineer, New York

IT has often been taken as a matter of course that the addition of an ordinary water filter either of the slow sand type or the mechanical type would be sufficient to bring the water to a condition of perfect purity in all its properties and make it absolutely satisfactory and sufficient for all drinking purposes. There seems no doubt that a water filter can only affect so much and no more in the way of bacterial purification. Having in mind limits such as these, it will be necessary to determine how much of a burden the condition of the raw water will impose on the filter.

B. Coli Determination

A water may have a very large number of bacteria and still be absolutely harmless. The determination of B. coli has come to be recognized to be the most satisfactory of the possible methods of determining the pollution of a water. B. coli of itself is not, of course, any direct indicator of disease-bearing bacillus. Is is only a very indirect evidence of the possibility of recent fecal pollution.

An International Joint Commission, composed of appointees of the United States and of Canada, has been investigating the pollution of the international boundary waters, with the idea of determining to what extent pollution must be limited in order not to endanger the health of the communities on the two sides of these boundary waters. The best that can be done with the data at hand is to consider all these data, properly weigh them, and on the basis of a rather general judgment come to some conclusion on what is a proper limit of B. coli in water to be applied to the filters. Such a conclusion can by no means be considered an exact judgment, and should be considered rather an average than a rigid limit for any particular case. This standard specifies that water applied to filters should show by the presumptive test not more than 500 B. coli per 100 cu. cm. of water as a yearly average, meaning by this that B. coli should not be found more than 50 per cent of the time in 0.10-cu. cm. samples. For averages for shorter selected times, monthly, weekly, or daily, the allowable B. coli content may be considerably higher. It is believed that for this purpose the averages based on a year's readings are more useful than averages for a shorter time with a correspondingly different standard of allowable B. coli.

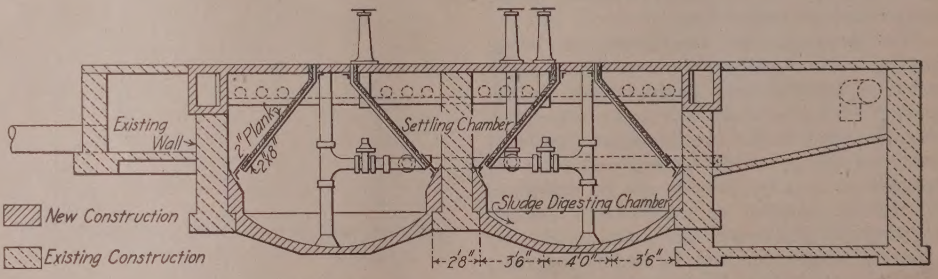
The bacterial efficiency of a filter is not an invariable quantity. Roughly speaking, 98 to 99 per cent may be placed as a fair average under ordinary conditions. With these conditions in mind, it seems reasonably safe to say that a water having in its raw form a coli content not exceeding 500 per each 100 cu. cm., based on yearly averages, will show in the water supplied to the consumers something not more than five to ten B. coli per 100 cu. cm. Such water is believed to be a fairly safe water, when properly sterilized, for drinking purposes and for all other domestic uses.

Remodeling a Septic Tank and Contact Filter Sewage Plant

By ALEXANDER POTTER
Consulting Engineer, New York

BY changing old septic tanks into two-story Imhoff tanks and converting existing contact beds into sprinkling filters the sewage treatment plant at Moorestown, N. J., built in 1901 to treat 250,000 gal. daily, has been remodeled to handle a daily flow of 500,000 gal.

From a grit chamber sewage entered an open brick septic tank 75 ft. long, 25 ft. 6 in. wide, with an average depth of 1 ft. Two 20-in. brick walls divided it into four equal compartments arranged so that two, three of four of the chambers could be used at any one time.



CROSS-SECTION SHOWING OLD WORK AND MODIFICATIONS

The contact bed was divided into four units, each 85 ft. x 42 ft. area, each inclosed by 16-in. brick walls. Three of the beds were filled to a depth of 4 ft. with slag ranging in size from ¾ to 1½ in.; the fourth bed was filled with cinders.

The work of remodeling consisted in removing the existing bottom and excavating to an additional depth of 2 ft. 4 in. As the new bottom is carried below the foundation walls of the old tank it was built in the form of an arch to give the necessary stability to the walls and to assist in the removal of the sludge. In the old septic tank the level of the liquid was maintained at El. 15. In the remodeled tank this was raised to El. 15.5, necessitating the raising of the outside walls a height of 6 in. These changes increased the depth of the tank from 7 ft. to 9.5 ft.

The remodeled tank consists of four units each of which is again divided into three compartments by a false bottom constructed of 2-in. creosoted yellow pine. This false bottom makes a slope of 40 deg. with the vertical. The upper two compartments are settling compartments and the lower and larger compartment is the sludge digestion compartment. The total settling capacity amounts to a retention of 1.35 hr. when the plant is operated at the rate of 500,000 gal. daily. The total capacity of the sludge digestion chamber figured below the level of the walls is 5470 cu. ft., about 50 per cent larger than required by established practice. Three 6-in. sludge pipes extend down into the sludge digestion chamber of each unit.

Cost of Remodeling

The cost of remodeling the plant and enlarging it 50 per cent to adapt it to the present flow was as follows:

Cost of Remodeling Plant

Remodeling septic tank into two-story tank.	$3,100
Construction of dosing tank, siphon and piping	1,800
Sprinkling filter, ¼ acre	8,300
Sludge bed and piping	300
Additional piping around plant	1,300
Final settling basin	500
Total	$15,300

The cost of remodeling the contact beds into a sprinkling filter was somewhat more than was expected as it was found that less than 10 per cent of the filter medium of the original beds could be used in the new filter.

Controlling Discharge of Inflammable Wastes into Sewers

By N. S. SPRAGUE
Superintendent, Department of Public Works, Pittsburgh

THE problem of preventing explosions in sewers can be solved in two ways—either by sealing all openings into the sewers or by regulating or excluding the discharge of inflammable wastes. Ignition of gases in the sewers could be prevented by sealing all openings, but this would prevent inspection and create impossible working conditions inside the sewer when repairs became necessary. Moreover, the sealing of the sewers would not prevent ignition at chambers, pumping stations and disposal plants. In addition to the foregoing, there are other reasons which would make the sealing of the sewers impracticable and inadvisable.

The exclusion of inflammable wastes from a sewer system brings up the question of how it shall be accomplished. The regulations of the Municipal Explosives Commission of New York, adopted Jan. 3, 1912, require the installation of oil separator traps or similar apparatus. Boston requires a special trap which will prevent the discharge of objectionable wastes into sewers, and Chicago has regulations similar to those of New York. It is most desirable that the necessity for such regulations be demonstrated and the efficiency of any devices thoroughly proven before they are required by ordinance.

BASIS FOR LEGISLATION

It would be best from the standpoint of enforcement to include in a single ordinance regulations covering all phases of the discharge of wastes of all descriptions into the sewers. Such an ordinance should contain the following:

A. Prohibition against the discharge of any inflammable gas, volatile inflammable liquid, inflammable liquid, oil or gas, or any calcium carbide or residue therefrom, or any liquid or other material or substance containing inflammable gas or which would evolve an inflammable gas when in contact with water or sewage.

B. Regulations as to how sewer connections with establishments from which the foregoing wastes emanate may be made. This may or may not require the installation of special traps, separators or similar devices.

C. Provision for the examination and approval of all intercepting devices and provision for their inspection, maintenance and operation.

D. Provision with regard to the discharge or placing of obstructing material in any part of the sewer system.

E. Regulations as to the discharge of steam or hot liquid or gaseous waste into the sewers.

F. Regulating the location of gas pipes in city streets with reference to the sewer; prohibiting the placing of gas pipes close to or within the masonry of sewers.

G. Prohibiting connections from manholes, gate boxes, or other apparatus of public service corporations to the sewers, except in an approved manner and when properly trapped.

It would appear desirable, in the interest of public safety, where oil separators or similar devices are installed, for the municipality to undertake the final disposition of the residue rather than entrust it to the individual. The importance of the problem and the necessity for its strict and effectual regulation has been amply and forcefully demonstrated by recent violent and destructive explosions.

Pittsburgh, immediately after its second sewer explosion, set about to make an investigation and study with a view of preventing a repetition of such disasters. This investigation is being conducted jointly by the city and the local office of the U. S. Bureau of Mines, which has rendered valuable assistance and advice. The purpose of this investigation, which is still in progress, is: First, to locate all possible sources from which gasoline or other explosive wastes might enter the sewers; second, to determine by a series of examinations and tests the location of the sources where the waste was discharged; third, to determine the presence, extent and quantity of vapor within the sewers; fourth, to ascertain by experiment the effect and behavior of gasoline dumped into the sewer in different quantities and at different intervals.

Experimental Sewage Treatment Plant in Brooklyn

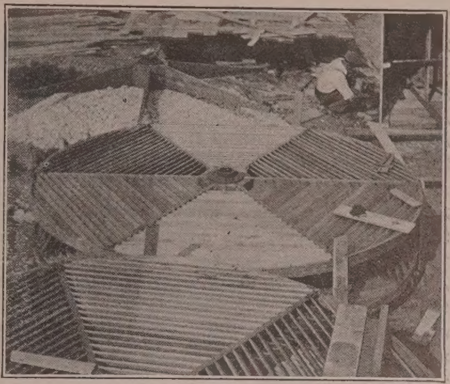
By GEORGE T. HAMMOND

Bureau of Sewers, Brooklyn, N. Y.

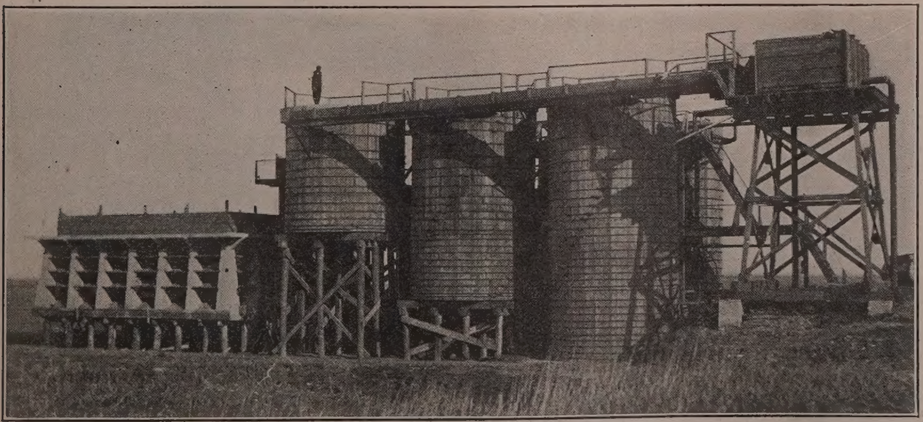
An experimental plant for sewage disposal investigations has been designed and installed by the Bureau of Sewers, Brooklyn, N. Y., in response to a resolution of the Board of Estimate and Apportionment of the City of New York, which authorized, for the purpose of constructing the plant and carrying on the experiments, the sum of $50,000.

The plant consists of three Imhoff tanks, each of different depth but with other dimensions equal; six sprinkling filters, two of which receive forced aeration within the mass of the medium; various tanks and apparatus for the investigation of sewage treatment by forced aeration; secondary settling tanks for the sprinkling filters and the sewage treated by forced aeration; a plain settling tank for crude sewage in connection with an airtight sludge digestion tank, which receives the settled matters and sludge from the plain tank, being in effect the two essential portions of an Imhoff tank separated; a roughing filter; ten sludge drying beds; various experiments for screening sewage, and for drying sludge, including a fixed mesh screen, a rotary disk type screen, and a canvas vacuum filtration system; various provisions for disinfection experiments, etc. The mechanical plant consists of steam-actuated sewage pumps and an air compressor.

The sewage for experiments is taken from the sewage passage between a silt basin and the disposal plant, and is practically free from grit. It is discharged from the pumps through an 8-in. iron pipe into the quieting tank, which supplies sewage to the various units of the experimental plant by gravity. For measuring compressed air, venturi meters were provided.



DEFLECTORS FOR AERATING TANK



IMHOFF TANKS AND SPRINKLING FILTER AT BROOKLYN SEWAGE PLANT

The Imhoff tanks are of pine staves 3 in. thick, with round iron hoops. Each tank is 15 ft. in internal diameter and rests upon a yellow pine platform, supported by caps carried on piles. The material of construction of the sedimentation chambers is pine, so put in as to be easily removed and reconstructed, as may be desired in the course of the experiments.

AERATION OF SEWAGE

Direct aeration experiments may be carried out with raw sewage supplied from the quieting tank, or with the effluent of the Imhoff tanks. The principle direct aeration experiments provided for are to be carried out by means of an aerating siphon, and an aerating tank. Experiments will also be made with sprinkling filters supplied with compressed air through a grid placed within the mass of medium. The aerating tank is a design developed from experiments made at the Twenty-sixth Ward sewage works, in 1911, by Col. William M. Black and Prof. Earle B. Phelps, which gave much promise. Other experiments will be made than those mentioned.

The siphon aerator is an application of the siphon air compressor principle to the aeration of sewage, proposed by the late C. C. Beddoes, who obtained a patent covering the use of the siphon for sewage aeration. It may be operated with raw sewage or Imhoff effluent. The flow of sewage is led, by gravity, to the bell at the top of the siphon down-take pipe, into which the sewage falls, entraining or sucking the air in with it, and passing vertically downward through the pipe with considerable velocity, the entrained air becoming compressed. It is claimed that the sewage exposed to air under pressure absorbs a greater portion in consequence of the pressure, as the volume of air absorbed will be in proportion to the pressure.

The tank aerator is for the purpose of experimenting, both upon crude sewage and Imhoff tank effluent, with forced aeration, either by fill and draw or constant control. It is a tank 12 ft. in diameter and 25 ft. 8 in. in height. A grid for supplying compressed air is placed at the bottom of the tank, upon 7½ in of broken stone, the same depth of broken stone being placed over it. The air is discharged into the broken stone surrounding the grid, which tends to break up any upward streaming effect. Through the central axis of the tank is placed a vertical 4-in. pipe which serves to center and support the deflector disks, of which there are nine, provided for the purpose of deflecting the downward flow of sewage and upward flow of air bubbles, so as to obtain even distribution of both air and sewage. The deflectors are designed in the form of a wheel with a hub which is of iron; six radial arms are provided between which slats are placed. The slats in each alternate deflector are set at angles alternating from and toward the center in order to give the sewage a sinuous motion in passing downward.

The sprinkling filters, all of which are served by a single group of dosing tanks, are divided into two groups. The first consists of four filter beds of the ordinary type; the second of a tank 12 ft. in diameter and 16 ft. high, in which are placed two beds. A partition wall divides the tank into two equal parts and each side is filled with stone filtering medium to the same depth.

The portions of the plant not yet completed include the major portion of the screening apparatus of which two Reinsch-Wurl screens are intended to constitute an important part. It is intended that the screens shall remain a permanent part of the proposed sewage disposal plant to be installed at this location. Each screen will have a capacity of 6,000,000 gal. of screened sewage per day, giving a total of 12,000,000 gal.

Bleeding and Swelling of Yellow Pine Paving Blocks

By C. H. TEESDALE
U. S. Forest Products Laboratory, Madison, Wis.

BLEEDING of oil from paving blocks and expansion of the wood due to absorption of moisture after being laid in the street have been the subject of investigation conducted by the U. S. Forest Products Laboratory at Madison, Wis.

MATERIALS USED

Green long-leaf pine and thoroughly air-dried long-leaf pine, rapid growth loblolly pine, and eastern hemlock were used in the work. Standard long-leaf pine paving block stock was used where possible. The blocks used were 4 in. wide, 8 in. long and 4 in. deep.

Two preservatives were used in the investigation of bleeding. One was a coal-tar creosote with a specific gravity of 1.07 at 60 deg. C. The other was a 50-per-cent mixture of this creosote with a by-product coke-oven tar having a specific gravity of 1.17 at 60 deg. C., and containing about 6 per cent free carbon. This mixture was believed to be comparable to much of the paving oil used for treating blocks.

In the investigation of swelling, a gas house tar was used which contained 30 per cent of free carbon.

The blocks were treated in a small experimental cylinder in which pressure and temperature conditions were under accurate control. The preservative was applied to the blocks under a pressure of 140 lb. per square inch until the desired absorption was obtained. A temperature of 180 deg. Fahr. was maintained throughout the treatment. When preliminary vacuums were drawn, the period was 1 hr., and the intensity generally 26 in. Steam periods and pressures are stated on the figures in each case. Two blocks were included in each treatment.

BLEEDING TESTS

After treatment the blocks were placed in an oven in tin boxes, and subjected to a constant temperature of 120 deg. Fahr. until the oil ceased to bleed from them. Blotting paper was used to absorb the oil as it came frome the blocks. Weights were taken at suitable intervals, corrections being made for losses by volatilization.

SWELLING TESTS

After treatment brass tacks were driven into each face of the blocks to facilitate measuring. All measurements were made over these tacks with a vernier caliper to 0.001 in. Two kinds of tests were made. Some of the blocks were allowed to soak in water until they ceased to increase in size. The remainder of the blocks tested were placed on a sand cushion and sprinkled daily until expansion ceased. Measurements were made at frequent intervals at first, these intervals being lengthened when the blocks changed in volume less rapidly.

GENERAL CONCLUSION

The tests seem to indicate that long-leaf pine paving blocks should be treated in the green condition after being well steamed. All blocks, even if thoroughly air-seasoned, should be well steamed. While it is true that a preliminary and final vacuum greatly retarded bleeding of air-seasoned wood, a preliminary vacuum will tend to make the absorption of oil too rapid during treatment, resulting in uneven penetration. A steaming period is, therefore, advisable to render the absorption less rapid and allow a longer and more intense pressure period to be applied. Furthermore, if seasoned blocks are steamed they will take up moisture and expand and should be less liable to give trouble from swelling after laying in the street. For these reasons it would be preferable to treat green material when it is possible to obtain it.

If for any reason the blocks can not be laid soon after treatment they should be covered and perhaps wet down occasionally to prevent them from drying out. It is likely that if the blocks are wet when laid, expansion troubles will be much reduced, provided a good job of laying is done.

It would seem to be desirable to give a vacuum treatment after the steaming period and also after the oil has been removed from the cylinder. If tar mixtures are used, a final steam bath should succeed the final vacuum to remove carbon and dirt from the blocks.

Absorptions of over 16 lb. per cubic foot hardly seem necessary. Data are available which show that heavier absorptions do not greatly retard swelling and they tend to increase bleeding.

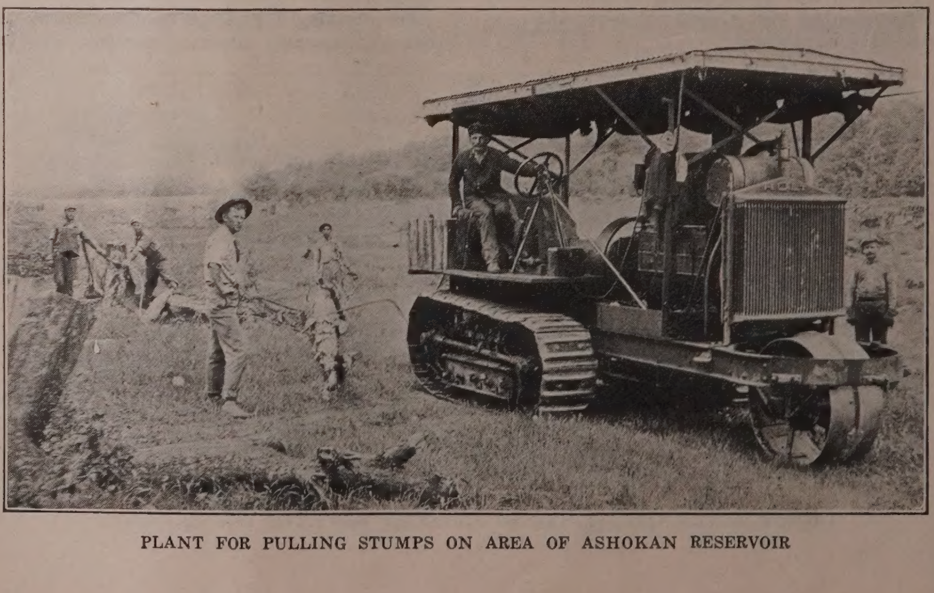
It seems very likely that the reasons why some pavements bleed while others do not may very often be traced to the method used in treatment. A plant treating green material would resort to a steaming and vacuum treatment with the result probably that the blocks would give no trouble. The same plant, perhaps, would later treat seasoned material without steaming it or giving it a vacuum treatment. This would be the simplest method of treating such timber as much time would be saved, and these operations would seem unnecessary. When such blocks are placed in the pavement, however, there is considerable probability that bleeding would follow. The author hopes that the society will consider the advisability of adopting a standard specification for treatment that will take into consideration the influence that methods of treatment may have, both on bleeding and swelling.

Stump Pulling at Ashokan Reservoir

Use of Traction Machine and Wire Cable, with or without Block and Tackle, on 2400 Acres of Grubbing

THE construction of the 132,000,000,000-gal. Ashokan reservoir for the New York City water supply from the Catskill Mountains involved about 9500 acres of clearing, most of which was heavily wooded country, and 2400 acres of grubbing. The specifications require that the stumps either be cut flush with the surface of the ground or pulled.

Pulling is accomplished by the contractor, F. Cogan & Company, with a traction machine and a wire cable. When a single part of the cable does not readily dislodge the stump a tackle is used. In many cases it has been found more convenient to pull up trees 1 ft. in diameter with this machine than to fell them.



PLANT FOR PULLING STUMPS ON AREA OF ASHOKAN RESERVOIR